MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY

Level 5 Drinking Water Operator Guide

(Rev. 10/2021)

Introduction

This guide is intended to provide basic information for persons preparing to become operators of small public water systems, mostly nontransient noncommunity water supplies. This guide is also a reference for existing Level 5 certified operators. This guide may be of use for operators of small community systems; however, there are a few differences in some aspects of the community versus noncommunity water supply regulations.

The Safe Drinking Water Act; 1976 PA 399, as amended requires all community and nontransient noncommunity public water systems and certain transient noncommunity systems (those that treat for water quality purposes or add chemicals to the water) to have a certified operator in charge of the water system.

Disclaimer

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Chapter 1

The Federal Safe Drinking Water Act was passed by Congress in 1974, giving the United States Environmental Protection Agency (U.S. EPA) the responsibility for establishment and enforcement of public drinking water standards nation-wide. Under a primacy agreement U.S. EPA has delegated the authority to administer and enforce the Safe Drinking Water Act requirements to the State of Michigan. The enactment of the Michigan Safe Drinking Water Act, 1976 PA 399, and Administrative Rules, as amended (SDWA), allows the Michigan Department of Environment, Great Lakes, and Energy (EGLE) to assume primary enforcement authority and responsibility for a comprehensive public water supply program in Michigan. The program includes regulations for community, noncommunity and other public water supply systems.

The Federal Safe Drinking Water Act undergoes reauthorization by Congress every ten (10) years and Michigan has enacted equivalent standards to maintain primacy. It is expected the regulation of public drinking water systems will continue to be a dynamic process. Under an annual contract the local health department (LHD) sanitarians perform many of the Noncommunity Drinking Water Program duties granted to the State of Michigan under the primacy agreement.

Program duties involve routine inspections of existing noncommunity water supply systems (NCWS), issuance of permits for new or expanded supplies, ensuring that water sampling is done at required frequencies, making sure steps are taken to protect public health and returning a supply to compliance when violations of the SDWA occur. Government staff as well as the facility owner and operator are all responsible for ensuring public health and safety.

Public Water System Classification

The SDWA defines a public water system. All facilities meeting the definition of a public water system are required to meet the legal requirements of the SDWA in Michigan. Keep in mind that “providing water” means that water can be used in the following examples; drinking, food preparation, ice making, bathing, hand washing, showering, tooth brushing, or dishwashing.

Three Classifications of Public Water Supplies (PWS)

- Type I – Community (CWS) or Municipal Supply
  - A PWS that provides year-round service to not fewer than 15 living units or which regularly provides year-round service to not fewer than 25 residents.
- Type II – Noncommunity Supply (NCWS)
  - A PWS that is not a community supply, but that has not fewer than 15 service connections or that serves not fewer than 25 individuals on an average daily basis for not less than 60 days per year.
- Type III – All Other Public Supplies
  - Examples include grade a dairy farms and small apartment complexes.

1.1 Noncommunity Water Supplies in Michigan

Michigan is home to nearly 10,000 noncommunity supplies. Examples include schools, childcare centers, restaurants, churches, campgrounds, motels, businesses, and industries that use a well as a source of drinking water for their customers, students, and employees. The majority of noncommunity supplies are called transient noncommunity water supplies (TNCWS) and serve people at places such as restaurants, motels, highway rest stops, and parks. However, some supplies serve the same individuals on a regular basis, such as schools and places of employment and are called nontransient noncommunity water supplies (NTNCWS). All noncommunity supplies must maintain approved water systems and meet drinking water standards for acute contaminants such as coliform bacteria and nitrate. Those that serve the same consumers on a regular basis, the NTNCWS systems, must also monitor for additional drinking water contaminants that can have long term health affects over time with repeated exposure. In addition, all NTNCWS systems are required to have a certified drinking water operator.

NCWS can be further divided into Type IIa and Type IIb depending on the average daily water production. Type IIa are those averaging 20,000 gallons per day or more. Most NCWS in Michigan are Type IIb.

Nontransient Supply Definition:
A noncommunity supply that serves not fewer than 25 of the same persons on an average daily basis more than 6 months per year. This definition includes water supplies in places of employment, schools, and daycare centers.

Transient Supply Definition:
A noncommunity supply that serves 25 or more different individuals a day at least 60 days of the year (or 15 or more service connections). Examples include motels, churches, golf courses, restaurants, parks, and highway rest areas.

1.1.1 Water Supply Serial Number (WSSN)

In Michigan, each NCWS is identified with a specific WSSN. The LHD staff assigns the WSSN when a facility is identified as a noncommunity water supply. A facility may have more than one drinking water well on the property, and each well is considered a different source. The individual wells are issued a Source ID Number, typically starting with 001 and continuing in succession (002, 003, etc.).

The WSSN and Source ID Numbers are very important and are used in identifying water sample results with the facility. The WSSN and Source ID Number MUST be included on all laboratory water sample analysis forms. Failure to include these numbers on the water sample analysis form may result in the NCWS receiving a monitoring violation.

1.1.2 Water System Classification

Like operators, water systems are classified using the same nomenclature.

Table 1.1 Classification Level of the Water System

Class of System	Description
F	Systems using surface water or ground water under the direct influence of surface water or any system with complete treatment.
D	Systems with limited treatment.
S	Distribution systems and no treatment or treatment that does not require public health related oversight.

1.1.3 Noncommunity Water Supply Status Change

It is the facility owner’s responsibility to document any changes in status, ownership or mailing addresses to the LHD.

What Constitutes a Change?

- The facility has closed
- The facility has changed ownership
- The facility has changed its status (changed from Type II to Type III)
- The facility has hooked to municipal water
- The facility has a different mailing address or name

1.2 Michigan's Drinking Water Regulatory Agencies

Department of Environment, Great Lakes, and Energy
The State of Michigan adopted the federal safe drinking water regulations and obtained primacy to enforce it. EGLE staff are in Lansing and district offices. The state authorized and contracts with LHDs to provide primary direct service to noncommunity system owners and operators. EGLE staff work closely with LHD staff and system owner and operators to maintain safe drinking water supplies.

Local Health Departments (LHD)
Noncommunity program coordinators in the Environmental Health division at LHDs provide noncommunity program oversight and technical assistance for required water quality monitoring and reporting in accordance with the SDWA.

Chapter 2

Operator Certification

To improve the safety of PWS through compliance with operation, maintenance and sampling requirements, amendments to the Federal Safe Drinking Water Act require that certain public water supplies have a certified drinking water operator.

Certified operator means an "operator who holds a certificate." The operator may be the owner of a PWS, or the person designated (or hired) by the owner as the responsible individual in overall charge of the water system. This person makes decisions regarding the daily operation of the PWS that could directly impact the quality and quantity of the drinking water. The certified drinking water operator is responsible to operate and maintain the waterworks system and protect public health. The PWS shall have a plan in place for proper operation of the system when the operator in charge is not available.

A drinking water operator is certified for a 3-year period, is responsible for demonstrating knowledge and ability to operate the system, and for keeping up to date on the SDWA regulations. This is accomplished through continuing education credits (CEC). It is the responsibility of the operator to renew their certificate by submitting (to EGLE) an application for renewal on the form provided by the department. To renew, the operator of a Level 5 NCWS, must have received at least nine (9) hours of continuing education training in the previous three (3) years which equates to 0.9CEC's.

The SDWA requires certified drinking water operators for all NTNCWS and for TNCWS that employ certain water treatment processes. Operators must be certified at a level equal to or greater than the classification level of the water system (F, D, or S).

2.1 Certified Operator's Responsibilities

Generally, a Level 5 certified operator for a NCWS does not always have to be on-site. However, the NCWS is required to have in place a plan for proper operation of the system when the operator in charge is not available. NCWS with treatment will require more oversight than systems with no treatment.

Typically, the operator arranges for repairs or disinfection in the case of a problem with the NCWS, or for bottled water if an alternate temporary supply is necessary. The operator ensures the sampling is being done correctly and on schedule and reported to the regulatory agency as required. The operator keeps the records available, up to date and properly posts any public notices that are required. The operator implements the emergency action plan of the NCWS. The operator is also in charge of water sampling or designating another person to collect samples when the operator is not available. The operator will be invited to accompany the health department during treatment surveillance visits and sanitary surveys.

2.2 Level 5 Operator Certification Procedures

To become a Level 5 certified drinking water:

1. Complete and mail an exam application to EGLE Operator Certification and Training Unit. Application must be received by EGLE not less than 45 days before the announced examination date.
   Refer to the website: Michigan.gov/EGLEOperatorTraining.
2. Demonstrate knowledge of the SDWA and the operation of a public water system by passing an exam prepared by EGLE with a score of 70 percent or better. Persons passing the exam will receive a certification document indicating their operator identification number and expiration date.

Third Party Operators
Many NCWS certified operators are the owners or employees of the facility, however a third-party contractor may be hired by the PWS owner provided they are certified at the level required by the classification of the NCWS, or they are certified at a higher level. All certified drinking water operators, no matter whether they are employed within or hired from outside the NCWS, have the same responsibilities of operating and maintaining the system, meeting all SDWA regulations, and providing safe drinking water to the public.

A certified operator may operate any waterworks system as follows:

- Within a classification at or below the level of their certificate.
- At a different classification as follows:
  - An operator who holds an F certificate meets the qualifications to operate a D treatment system of comparable numerical classification.
  - An operator who holds an F certificate or D certificate meets the qualifications to operate a class S-5 system.

2.3 Continuing Education and Renewal of Certificates

Once certified, all drinking water operators must take continuing education classes to renew their certificates. Operator certification is valid for three (3) years. Within that three-year period, Level 5 operators in Michigan are required to obtain a minimum of nine (9) hours of EGLE approved continuing education credits (0.9 CEC). If the certificate expires, the person must reinstate the certificate within one (1) year, otherwise, they will have to pass the examination to become certified again. A Level 5 certificate holder will receive a 90-day grace period and still be able to reinstate their certificate with 0.9 CEC's. After the 90-day grace period, a Level 5 certificate holder will need 0.9 plus 0.1 for each subsequent quarter (90 days) up to one (1) year after the expiration date. The end date for each quarter will be January 15, April 15, July 15, and October 15. If the individual does not meet the pro-rated continuing education requirement by October 15, 2021, he or she will need to re-test for the desired certification.

This certification is yours, like your driver's license. We recommend you use your home address, phone number, etc., when filling out the exam application. Your renewal form and other important information regarding your certification are sent to the address provided on the exam application form. Include the information for the facility(s) you will be working at in the "Business" section. Do not forget to include ALL facility WSSN's.

2.4 Owner Responsibilities

Although the owner of a NCWS may hire someone to do one or more of the following duties, the owner is ultimately responsible for providing safe drinking water and meeting all the legal requirements that apply to the water supply.

NCWS owners must:

- Provide an adequate supply of safe water to the public
- Maintain and operate the system in a safe and sanitary condition
- Collect required water samples
- Notify the public in cases of noncompliance
- Obtain permits for construction or alteration of water well supply
- Maintain NCWS records
- Notify the LHD within seven (7) days when the supply no longer has the services of an operator

At times, a well contractor, licensed plumber, or other water professional may need to be hired to assist with the water system.

Chapter 3

Water System Maintenance

Routine maintenance of the water storage, distribution piping, treatment devices, cross connections, safety, and security is typically the responsibility of the operator.

An operator should be able to:

- Identify possible sources of contamination in the area around the well
- Inspect physical components of the treatment and distribution systems
- Observe problems with equipment
- Know who to contact in case of repairs or emergencies

Image 3-1

An example of what an operator can look for:

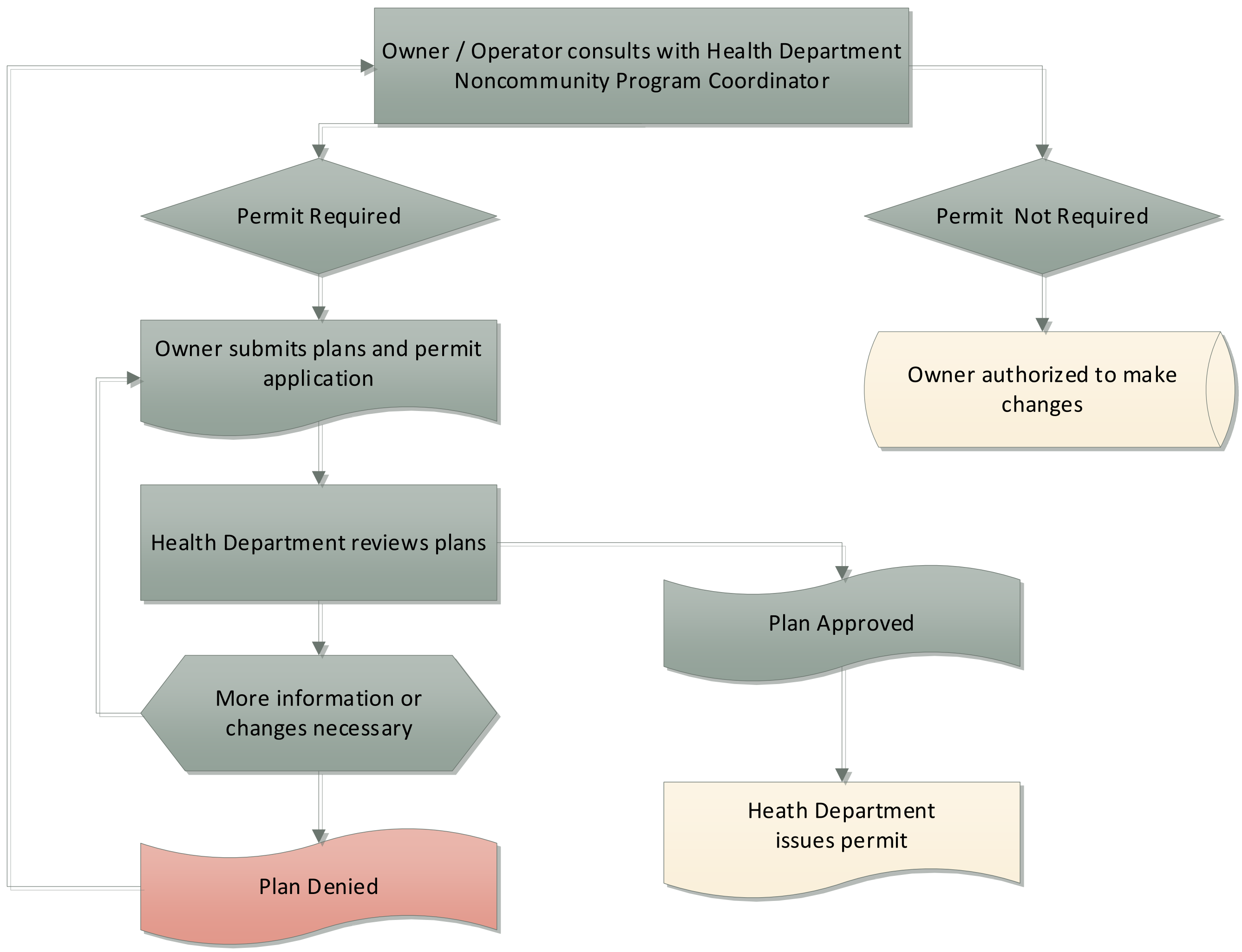
Look for problems at the well head. A depression in the ground around the edge of the casing can indicate grout has shrunk, collapsed, or cracked. If the casing can be moved around by pushing it, that is a bad sign. Cracking and gaps allow run-off and surface water to move down the outside of the well casing and contaminate the groundwater.

3.1 Essential Elements of System Operation and Maintenance

- Know the location of your well(s) and inspect on a routine basis. Inspecting it will alert you to any deterioration, damage, or other problems.
- Maintain a secure and intact well cap. Older well caps often do a poor job of keeping insects and other contaminants out of the well. If possible, replace older caps with an overlapping well cap that includes a compression gasket and screened vent.
- Be sure the well casing extends at least one foot above the ground surface to reduce the possibility of surface water or other contaminants entering the well. Avoid landscaping projects that reduce the distance between the ground and the top of the well casing to less than the required minimum distance. If necessary, a licensed well driller can extend the well casing to the proper height.
- Direct surface and roof runoff away from the well. Surface water should not collect near the well. Direct snowplows away from the well to avoid issues with snow melt.
- Direct vehicular traffic away from the well or surround the well casing with rigid posts or large rocks to help protect the well from damage. Delivery trucks, lawnmowers, snowmobiles, and other vehicles may damage wells. Sometimes well damage is below ground and not visible from the surface. Water quality degradation, inconvenience, and expensive repairs are often the result.
- To the extent possible, remove any potential sources of contamination from the area near the well. All new wells must meet the minimum isolation requirements for separation from potential contaminant sources.
- Operate and maintain all water treatment devices according to the manufacturer's specifications. This includes routine replacement of filter cartridges, maintaining an adequate level of salt in the brine tank if you have a water softener. Poorly maintained treatment devices often lead to water quality problems. It is important to take note of any changes in the operating characteristics of the treatment equipment as it may allow pathogenic organisms to pass through into the drinking water supply.
- Eliminate cross connections and dead ends in the plumbing system. A dead end, as the name implies, is a portion of your drinking water piping that does not have water regularly moving through it. Dead ends result in stagnant water that can affect water quality elsewhere in the system. Plumbing cross connections potentially allow contaminants to enter the potable water supply.
- Always have the plumbing system disinfected by a licensed well drilling contractor or a Master Plumber after repairs or modifications. New fixtures, piping, or other plumbing components can introduce bacterial contamination.
- All seasonal wells and plumbing systems must be disinfected and sampled for coliform bacteria prior to opening for the season by an authorized person, and the LHD representative contacted. All distribution system lines must be thoroughly flushed before approval for use.

- Prior to making changes to the water system, contact your LHD representative. A permit may be required.
- Know whom to contact in case of emergency if there are problems with your water system. This would include LHD staff, a well contractor, and a plumber.

NOTE: The owner is still legally responsible for compliance with the SDWA and must be informed by the operator when compliance issues arise.



3.2 Plan Review and Permits

The SDWA requires owners of NCWS obtain a permit from EGLE or its' representative (LHD) PRIOR to the construction and use of a NCWS source or treatment facility or in the event of alterations to the system. The purpose of the plan review is to verify the design complies with Michigan rules and standards, and that no system is installed that may endanger public health. The construction or alteration must be inspected and approved by the LHD before the water can legally be served to the public.

Consulting with the LHD noncommunity program coordinator in advance has also resulted in owner/facility savings both financially and time wise. If alterations, replacements, or repairs are made without consulting with the LHD, changes might not meet the requirements of the SDWA and the LHD has the authority to have the owner "undo" what was done at the owner's expense.

3.2.1 Steps PRIOR to Water System Changes

- Contact LHD for consultation on proposed, alteration or change to find out if a permit is necessary.
- Permit necessary: Submit construction details and acceptable scaled drawing (properly dimensioned) showing important aspects of the general layout of a proposed waterworks system or a portion of the system.
- LHD reviews and approves plan then issues a permit for the construction or alteration. A permit is also required for any treatment facilities which are to be used for public health purposes before the water may be used.
- Work may be started and completed according to the permit specifications.
- If permit is not necessary, the owner is authorized to make changes or alterations by the LHD without a permit.
- If the plans or information are incomplete, the LHD will request more information. The LHD will review information as it is received and either approve or deny the permit.
- If the plans or information do not comply with the SDWA regulations, the LHD will deny the permit and the changes or alterations cannot be made.

3.2.2 When a Plan Review is Required

- Plumbing construction/modifications
- Installation of water treatment systems
- Wells serving community water supplies

3.2.3 When Permits are Required

- Plumbing construction/modifications
- Installation of water treatment systems
- New or replacement wells serving noncommunity water supplies

Plan Review and Permit Application Forms can be obtained from the LHD in your area.

3.2.4 Revision of Approved Plans and Specifications

The owner must notify the LHD if changes to the approved permit are needed.

3.3 Treatment Permit Requirement

Treatment systems to meet drinking water standards, or that inject treatment chemicals into the water supply for any purpose also require a construction permit because of public health concerns if chemical injection is done improperly. This chemical injection includes, but is not limited to:

- Continuous disinfection with chlorine, ozone, or any other disinfectant
- Fluoride addition
- Phosphate injection to sequester iron or prevent leaching of lead or copper
- pH adjustment
- Potassium permanganate with greensand iron removal

Review Chapters 11 and 12 of this guidebook for more information on water system treatment requirements.

3.4 New Wells

A well construction permit is issued when the proposed construction details and well site are satisfactory. The LHD makes an initial site evaluation to approve the proposed well location. Final approval to put the well in use may be granted after the LHD has approved the well construction, pump installation, water sample analysis results, and has received a satisfactory well log from the driller.

3.5 Capacity Development

Construction of a new NTNCWS cannot begin until the owner has satisfactorily demonstrated the facility has the capacity to comply with the provisions of the SDWA. Existing supplies (typically transients) applying to become a nontransient water supply must also complete a Capacity Development form.

Capacity is defined as the overall capability of a water supply to reliably produce and deliver water meeting all national primary drinking water regulations in effect or likely to be in effect, on the date of commencement of operation.

Capacity encompasses the technical, managerial, and financial capabilities that enable the water system to plan, achieve, and maintain compliance with drinking water standards. The capacity development process should help educate the applicant about initial and future requirements and costs of being a NCWS owner.

3.6 Approved Standards

Equipment and Materials
Section 13 (2) of the SDWA requires that all water treatment chemicals at a NCWS have the NSF-60 certification and all products that come in contact with water at a NCWS have the NSF-61 certification. Also, Rule 505(e) of the SDWA states, "A supplier of water shall comply with all applicable state and local plumbing codes."

Well Construction
All public drinking water wells constructed in the state must meet the construction standards of the Michigan Water Well Construction and Pump Installation Code, Part 127 and installed by a Michigan licensed well drilling contractor. A well construction permit is also needed for a replacement or additional well.

3.7 Permit Denial

Rule 1307 of the SDWA states that the department may deny a permit request when it determines that a NCWS cannot provide a continuous and adequate supply of water meeting the state drinking water standards.

Chapter 4

Drinking Water Sources and Source Water Protection

Water for consumption, or potable water, comes from fresh water on the surface or underground aquifers. An aquifer is an underground water-bearing layer of gravel, sand, sandstone, shattered rock, limestone, or other geologic formation which is saturated, and which transmits water in sufficient quantities to serve as a water supply. Water is not naturally pure, no matter what source it comes from. In nature, all water contains impurities. Some impurities are harmless, while others may adversely affect human health. The SDWA is written to protect the public against harmful impurities that may be found in drinking water sources. A basic understanding of groundwater characteristics is important for the protection of our water sources and to provide safe drinking water.

4.1 Surface Water Sources

Few NCWS use surface water as a drinking water source. Surface water can be obtained from a river, lake, or other surface impoundment. Surface waters are exposed to many contaminants such as animal wastes, pesticides, insecticides, industrial wastes, algae, and many other organic materials. Compared to groundwater, surface water has high turbidity and suspended solids. Strict monitoring and treatment are required if this source is used for drinking water. Any facility using surface water as its drinking water source must provide complete treatment.

4.2 Groundwater Sources

Most water systems in Michigan use a well or wells. This means that they are using groundwater as a water source to meet their water needs. A water well is constructed into an underground aquifer. The well acts like a straw to pull water out of the ground and then transports it to the facility by use of pumps and pipes. Groundwater is generally less susceptible to contamination than surface water, but typically has higher concentrations of dissolved solids than surface water.

4.3 Aquifers

An aquifer is a saturated underground water-bearing formation capable of transmitting water. Some aquifers are better to use for drinking water purposes than others. An aquifer located below a thick confining layer of clay or dense soil material that liquids do not pass through easily or quickly, is less likely to become contaminated by surface materials and may serve as a better drinking water source. However, some areas in Michigan may only have one viable formation for drinking water.

4.4 Source Water Protection

Drinking water is vulnerable to being contaminated if the source is not protected. Source water contamination could create potential health problems and cause increased expenses for water system owners in their pursuit of correcting the problem or searching for a new source of drinking water. “Source Water Protection” refers to the efforts made by NCWS to protect their water supply source.

The 1996 amendments to the federal Safe Drinking Water Act required states to develop a Source Water Assessment Program (SWAP). A source water assessment is a study and report, unique to each water system that provides basic information about the water used to provide drinking water. SWAP was designed to identify areas that supply public drinking water, assess the susceptibility of those water supplies to contamination, and inform the public of the results.

Source water protection begins with maintaining isolation distances from any known source of contamination to the wellhead or water inlet and monitoring or relocating all existing contaminants that do not meet the minimum required isolation distance. It is the responsibility of the owner and certified operator to do what is needed to protect their source water.

4.5 Isolation Distances

Isolation distances are the minimum physical separations that are required between a well and a potential source of contamination. There are two types of isolation distances, “standard source” and “major source.”

Failure to meet isolation distances may contribute to contamination of the well and is considered a violation of the SDWA.

4.5.1 Standard Sources of Contamination

The Michigan SDWA establishes the standard isolation areas from any existing or potential sources of contamination, including, but not limited to, storm and sanitary sewers, pipelines, septic tanks, drain fields, dry wells, cesspools, seepage pits, leaching beds, barnyards, or any surface water, other area or facility from which contamination of the groundwater may occur, for PWS’s. (Act 399 - Rule 808).

4.5.2 Major Sources of Contamination

Michigan also established isolation distance requirements for PWS’s from known major sources of contamination, including, but not limited to, fuel storage tanks, large-scale waste disposal sites, land application of sanitary wastewater or sludges, sanitary landfills, and chemical or waste chemical storage or disposal facilities.

The LHD may require an increase or approve a decrease in the isolation distances based on hydrogeological data; what type of soil is found above the aquifer, the groundwater flow direction, well construction and the volume of the contaminant.

A well shall not be in an area subject to flooding and the ground surface immediately adjacent to a well casing shall be graded so that surface water is diverted away from the casing. The casing must extend at least 12 inches above grade. Surface flooding shall not be allowed closer than 25 feet from the well. (Act 399 - Rule 816)

Table 4-1: Isolation Distances to a Drinking Water Well

Noncommunity Well Type	**Minimum Distance to Contamination**	
	Major Source	Standard Source
Type IIa	2000 feet	200 feet
Type IIb	800 feet	75 feet

4.6 Multiple Barrier Protection

Over the years the principles of multiple barrier protection have become the foundation of Michigan’s drinking water programs. The primary barriers to prevent contamination and protect public health are proper location, construction, operation, and maintenance of sources and water systems supported by periodic monitoring to measure the ongoing integrity of the systems. There are numerous elements to each of these barriers that essentially make up the drinking water program. The elements include:

- Training and licensing of water well drillers and pump installers
- Strict construction codes for all water well location and installation
- Plan review and permitting of new construction or alteration of public water systems
- Training and certification of operators
- Source water assessments
- Cross connection control
- Treatment where applicable
- Regular sanitary survey inspections

Ongoing water quality sampling is required for all NCWS. This monitoring is very important, however periodic monitoring is not a substitute for multiple barrier protection (i.e., properly located, constructed, and operated water supplies) since exposure to contaminants has occurred by the time results from routine samples are known.

Similarly, treatment to remove or inactivate contaminants with public health implications is also not a substitute for a safe source. Continuous removal of contaminants that impact public health requires significant technical and operational expertise and regulatory oversight. Treatment is a last resort, especially for small water systems, and is far less protective of public health than relying on a source that is not contaminated.

4.7 Water Quality Safeguards

Continuous Positive Pressure

Prevents back siphonage and entry of contaminants
Result of adequate supply and storage and proper design
Loss of pressure = posting, chlorination, and sampling

Frequent Testing and Record Keeping

Informs you if there is a breech in system
Records let others know what has happened in your absence

Routine Maintenance

Well/pump, water storage, distribution piping, treatment devices, cross connections, safety, and security

Chapter 5

Drinking Water Quality

Groundwater is not “pure” water as it naturally contains some impurities. The cycle of water from precipitation, streams, lakes, etc. filters through layers of soil and rock in the ground, dissolving or adsorbing the substances it touches. Some substances are harmless; however, at certain levels minerals and man-made chemicals or wastes are considered contaminants that can make water unpalatable or even unsafe.

Groundwater is a “naturally protected” underground source and is less likely to become polluted than surface water. Groundwater typically has higher concentrations of dissolved minerals and lower turbidity than surface water. The type and concentration of dissolved minerals in groundwater can affect its usefulness for various purposes. If certain mineral constituents are present in excessive amounts, some type of treatment may be necessary to either change or remove the dissolved mineral before the water can be used. Most groundwater contains no suspended particles and practically no bacteria or organic matter. It is usually clear and odorless. These characteristics contrast with surface waters, which generally contain suspended matter and considerable amounts of bacteria.

Water quality can be grouped into three general categories: biological; chemical; and physical. Biological characteristics include the presence of organisms (viruses, bacteria, algae, and other microscopic organisms) alive or dead, and their metabolic products. Chemical characteristics include mineral content, pH, and hardness. Physical characteristics include color, turbidity, temperature, taste, and odor.

5.1 Biological Characteristics

Microbial contaminants such as bacteria, viruses, and microscopic organisms pose the greatest health risk challenge for water system owners and operators. Mild to moderate illness lasting days to weeks can result from exposure to microbial pathogens. Most serious health problems, even death, can result when people with weakened immune systems are exposed to pathogens.

Coliform Bacteria

Bacteria found in water, such as coliform, salmonella, Legionella, and *E. coli*, are generally attributed to human and animal wastes. The total coliform group of bacteria are found nearly everywhere in the environment, except in clean water. While most forms of coliform bacteria are harmless, their presence in drinking water can indicate that either the water source or the distribution system has been contaminated by an external source.

Specific types of coliform bacteria reside in the digestive tracts of humans and many animals. The presence of coliform bacteria, specifically *E. coli* (a type of coliform bacteria), in water is an indication that fecal matter is present, even if in small quantities. This is cause for concern because pathogenic bacteria may also be present in the water. The pathogenic bacteria are almost impossible to test for because they represent only a small portion of the total bacteriological count. The greatest proportion of intestinal bacteria is the coliform group, and tests for the presence of coliform bacteria are relatively simple and inexpensive.

Viral infection of drinking water supplies is another major concern in the protection of public health. Examples of waterborne viruses include enterovirus, rotavirus, and hepatitis. As with bacteria, the presence of viruses in drinking water may be associated with human wastes. If viruses are detected, immediate steps must be taken to rectify the problem.

Although most disease-causing microscopic organisms, or protozoa’s, are not naturally found in water, they can survive in water for a time. Examples include Giardia and Cryptosporidium. These organisms are parasites that enter lakes and rivers through sewage and animal wastes, but unlike most bacteria and viruses, they can be particularly difficult to detect and treat in drinking water. Cryptosporidium spores are resistant to chlorine and both parasites can easily pass through inefficient filtration devices. Proper disinfection and/or filtration, system maintenance, and regular system upgrades are essential to protecting human health from these pathogens.

Bacteriologic and protozoan pathogens are known to cause typhoid, dysentery, cholera, and some types of gastroenteritis.

5.2 Chemical Characteristics

Several chemical aspects of water are significant to water quality. Calcium and magnesium cause hardness in water. Alkalinity is important for corrosion control. Iron and manganese may cause staining of clothes and of plumbing fixtures. Chlorides cause the water to taste salty. Excessive amounts of fluoride may cause staining (mottling) of children's teeth (however in lower concentrations of about 1 ppm, it may help to prevent cavities). Nitrates and nitrites are an indication of chemical fertilizer pollution and can be very harmful to infants by causing a condition known as "blue baby syndrome." Some chemicals such as arsenic can cause cancer when consumed over long periods of time or in high concentrations. Minerals and chemicals such as mercury, lead, copper, volatile organics, pesticides, and herbicides can also cause serious health effects.

The chemical characteristics of water can be broken down into two main groups: organic and inorganic. Organic chemicals are carbon based, whereas inorganic chemicals are not. Organic chemical characteristics in water come from the breakdown of naturally occurring materials, introduction of contaminants from human activities, and the reactions that occur during water treatment and distribution. The most common organic chemicals come from the breakdown of natural materials such as leaves and plants, aquatic decomposition, and other natural by-products. Inorganic chemicals are mostly human made solvents, pesticides, herbicides, and other commercial and industrial products and may also be found in drinking water sources if the source is not properly protected.

5.2.1 Nitrates and Nitrites

Nitrates often reach the groundwater due to a breech in well construction or from leaching of farming and lawn fertilizers down to the drinking water aquifer. The decomposition of septic waste is also a source of nitrates. The presence of nitrates may be especially harmful to those with potential respiratory impairments including the elderly or young children (less than 6 to 12 months old).

Nitrates may be transformed into nitrites by bacteria in the digestive tract and may then be absorbed into the blood stream. In infant digestive systems, there is insufficient hydrochloric acid to kill nitrite-producing bacteria. Nitrites in the blood inhibit the transport of oxygen in the blood stream, which can cause shortness of breath, heart attacks or asphyxiation. Because the condition can create a bluish skin color, it is called "blue baby syndrome" (methemoglobinemia). High nitrate levels are commonly treated with ion-exchange or reverse osmosis systems. Boiling water increases the nitrate concentration.

5.2.2 Arsenic

Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. Arsenic occurs naturally in rocks and soil, water, air, and plants and animals. It can be further released into the environment through natural activities such as volcanic action, erosion of rocks and forest fires, or through human actions. Approximately 90 percent of industrial arsenic in the U.S. is currently used as a wood preservative, but arsenic is also used in paints, dyes, metals, drugs, soaps, and semi-conductors. High arsenic levels can also come from certain fertilizers and animal feeding operations. Industry practices such as copper smelting, mining and coal burning also contribute to arsenic in our environment.

Higher levels of arsenic tend to be found more in ground water sources than in surface water sources of drinking water. The demand on ground water from municipal systems and private drinking water wells may cause water levels to drop and release arsenic from rock formations.

Non-cancer effects can include thickening and discoloration of the skin, stomach pain, nausea, vomiting; diarrhea; numbness in hands and feet; partial paralysis; and blindness. Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.

Soluble, inorganic arsenic exists in either one of two valence states depending on oxidation-reduction conditions. If arsenic is found in groundwater, it is typically non-oxidized and is in a trivalent form called arsenite or As (III). Surface water has aerobic conditions and arsenic is found in its arsenate or oxidized pentavalent form, As (V).

5.2.3 Corrosiveness

Corrosivity is a complex characteristic of water related to pH, alkalinity, dissolved oxygen, total dissolved solids, and other factors. Corrosive water, in addition to dissolving metals (corrosion of toxic metal pipe materials such as lead can create a serious health hazard) with which it comes in contact, also produces objectionable stains on plumbing fixtures. Corrosivity can be a naturally occurring property that may be controlled by pH adjustment or the use of chemical stabilizers.

5.2.4 Dissolved Solids

The total concentration of dissolved minerals in water is a general indication of its suitability for use. Groundwater high in dissolved solids should be viewed as potentially corrosive to well screens and other parts of well structures, regardless of other chemical characteristics of the water. Excessive amounts of dissolved solids will adversely affect the disinfection ability of chlorine and may have a bad taste to it. Solid particles in surface water may be the cause of high turbidity which may have adverse effects on drinking water quality.

5.2.5 Hardness

Hardness is a characteristic of water caused mainly by the salts of calcium and magnesium and can cause aesthetic problems. They react with soap and produce a deposit called “soap curd” that remains on the skin and clothes and, because it is insoluble and sticky, cannot be removed by rinsing. Soap curd changes the pH of the skin and may cause infection and irritation. Soap curd picks up the dirt from laundry water and holds it on cloth, contributing to a gray appearance of white clothes, causes a ring around the bathtub and spotting on glassware. Excessive hardness causes deposition of scale in pipes and equipment, damage in some industrial processes, and it sometimes causes objectionable tastes in drinking water.

5.3 Physical Characteristics

5.3.1 Aesthetic Issues

Unpleasant appearance, odor, or taste may be of concern for water systems. Some major groundwater constituents that may cause aesthetic problems if in excess include silica, sulfate, sodium, chloride, magnesium, calcium, iron, and manganese. For example, excessive iron causes a “rust stain” and a potential for iron bacteria growth, too much sulfate causes a “rotten egg odor,” and high levels of sodium will give water a salty taste. Surface water sources may also contain substances that are aesthetically unappealing which may be eliminated from the water through treatment. Aesthetic problems may also indicate possible health hazards or the potential for reduced operating efficiency of well equipment and should not be ignored.

5.3.2 Taste and Odor

Taste and odor can affect the quality of water by tainting certain foods and vegetables and by reducing the palatability of foods cooked in water. The main sources of odor- and taste-bearing substances are harmless organic materials like iron bacteria, and certain inorganic chemical constituents such as hydrogen sulfide. Most taste and odor problems are solved by eliminating the substances that cause the problem. Treatment techniques include activated carbon filtration and/or oxidation using chlorination, potassium permanganate, ozonation or aeration.

5.3.3 Turbidity and Color

Turbidity is a visual haziness in water caused by the presence of insoluble suspended particles. Generally, turbidity is more common in surface water than groundwater because groundwater moves too slowly to carry particles of sediment. Turbidity is undesirable for health as well as for aesthetic reasons because turbidity can interfere with disinfectants by providing a hiding place for microorganisms.

Chapter 6

Water Quality Monitoring

Groundwater is typically a safe source of drinking water and events of drinking water contamination are rare. However, contaminants can enter the drinking water supply if any of the protective barriers are breeched. Heightened public awareness, concern for public health, and advancements of technology are factors behind legislative action to set national standards regarding the levels of contaminants in drinking water. Water quality monitoring has an important role in identifying breeches in the system that may threaten the safe and aesthetically pleasing water to its consumers, however, it is important to understand that a water sample is just a “snapshot in time” and one non-detect result does not necessarily indicate that the water supply is in compliance or free of contaminants.

Contaminants that are monitored in the public drinking water program include both acute and chronic contaminants.

6.1 Acute Contaminants

Acute contaminants may have the potential to pose an immediate health risk if consumed.

6.2 Chronic Contaminants

Certain contaminants may cause cancer or other ill health effects when consumed at relatively low concentrations over extended periods of time. These types of contaminants may cause chronic health problems. Examples include arsenic, benzene, atrazine, and lead. Chronic contaminants are monitored only at NTNC and community water systems because people served by these systems may consume the water for extended periods of time.

6.3 Water Quality Standards

There are potentially thousands of different contaminants that could find their way into drinking water systems that may be harmful to health. It is impractical to attempt to test for all possible contaminants. Priorities for testing are determined, in general, by the federal government which decides which contaminants to monitor based on national occurrence data, health effects and technology. The EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children.

The contaminants that the U.S. EPA established enforceable standards for are also called Primary Standards. There are other substances that the U.S. EPA has set Secondary Standards for based on aesthetic effects only. These are not enforceable; however, they may be used in establishing health advisories as needed. A printable table of U.S. EPA's National Primary Drinking Water Regulations can be found on this website: EPA.gov/Ground-Water-and-Drinking-Water/National-Primary-Drinking-Water-Regulation-Table. A summary is provided in Table 6-1.

6.3.1 Maximum Contaminant Level (MCL)

MCLs are established by the U.S. EPA for regulated contaminants. The MCL is the greatest amount of a contaminant allowed in drinking water. This is a standard set by EPA and enforced by local health departments contracted with EGLE. National Primary Drinking Water Standards are those established by the U.S. EPA for contaminants that affect public health, and MCL’s are assigned to these based on scientific research. Contaminants that are based on aesthetic effects only are not enforceable and are called Secondary Drinking Water Standards by the U.S. EPA. Secondary contaminants include substances such iron, manganese, and sulfate. If a water sample exceeds the MCL, it is a violation of the SDWA and precautionary measures, along with re-sampling, must be conducted at the facility.

6.3.2 Action Level (AL)

An AL is a contaminant concentration that if reached in a certain percentage of samples requires specified actions by the public water supply. Lead and copper are examples of contaminants that are assigned an AL rather than an MCL.

Table 6-1: Summary of Primary Drinking Water Standards

Contaminant	MCL or AL	Source(s)	Health Risk	Monitoring Frequency
Bacteria (Microbiological)	Confirmed Presence of Coliform Bacteria or *E. coli*	Naturally occurring in environment, human and animal wastes	Acute	Monthly, Quarterly, or Annual
Nitrate (Inorganic)	10 milligrams per liter (mg/L)	Animal wastes and fertilizers	Acute	Annual (increased for elevated results)
Arsenic (Inorganic)	10 micrograms per liter (ug/L)	Naturally occurring mineral in soil and bedrock	Chronic	3 years (increased for surface water or elevated results)
Lead and Copper	Lead = 15 ug/L Copper = 1300 ug/L	Brass fixtures, solder in plumbing and lead pipes	Chronic	2-consecutive 6-month samples (decreased after 1 year and 2 years)
Inorganic Chemicals (IOC's)	Specific for each contaminant[3]	Metals, salts, etc.	Chronic	3 years
Synthetic Organic Compounds (SOC's)	Specific for each contaminant[3]	Compounds used for industrial and agricultural purposes	Chronic	Quarterly (reduced based on results and source vulnerability)
Volatile Organic Compounds (VOC's)	Specific for each contaminant[3]	Compounds used for industrial and manufacturing purposes	Chronic	Quarterly (reduced based on results and source vulnerability)

6.4 Sampling Techniques

It is critical that the person collecting the water samples does not mistakenly contaminate the sample bottle and follows all procedures indicated on the laboratory sample instruction sheet. Failure to properly collect the sample may result in false sample results, public notification of contaminated water, and additional sampling requirements.

6.5 Laboratory Sample Forms

Forms to be submitted to the laboratory must be completed in full and sent along with the sample for analysis. It is important to complete every blank properly. Missing or incorrect information may result in laboratory confusion for reporting purposes, non-analysis of the sample, and regulatory problems as well as future confusion with water quality analysis history.

6.5.1 Reading and Understanding Lab Results

After the laboratory has analyzed the water samples, they will send the results. If there is an immediate problem with the results, such as the presence of coliform bacteria that would require immediate action, the laboratory will call the sample collector. If any water sample result exceeds the primary standard, an MCL violation occurs, and precautionary measures may be immediately put in place. If you receive a water result with detections or have questions about your water test results, contact your LHD immediately.

Figure 6-1 is an example of a Coliform laboratory result from the State of Michigan Laboratory. This result is showing a coliform positive result, which means there was coliform bacteria detected in the water sample. When this happens, call your LHD immediately for further instruction. This guidebook describes those actions in section 6.13.

Note all the collection information that is included on the analysis request form. It is important to include all the System Information when submitting water samples to a lab.

Figure 6-1

EGLE
MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

MICHIGAN DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY
DRINKING WATER LABORATORY
USEPA Region V Drinking Water Cert. No. MI00003

P.O. Box 30270
Lansing, MI 48909
TEL: (517) 335-8184
FAX: (517) 335-8562

Official Laboratory Report

Report To: [redacted]

Sample ID: **LJ3**[redacted]
Work Order: **01**[redacted]

System Name/Owner:	C[redacted]	WSSN/Pool ID:	20[redacted]
Collection Address:	4[redacted]	Source:	TYPE II
Collected By:	M[redacted]	Site Code:	
Township/Well#/Section:	A[redacted]	Collector:	Other
County:	Hillsdale	Date Collected:	12/08/2020 09:20
Sample Point:	S[redacted]	Date Received:	12/09/2020 10:38
Water System:	Treated/Softened Private Well	Purpose:	Routine Monitoring

TESTING INFORMATION					REGULATORY INFORMATION		
Analyte Name	**Result**	**Units**	**RL**	**Date Tested**	**MCL/AL**	**Method**	**CAS #**
Coliform Organisms per 100 mL	**POSITIVE**			**12/09/2020**		**SM 9223 B**	**TC-00-B**

Coliform bacteria detected. By law, four repeat samples must be collected within 24 hours of this notification. At least one of the four samples must be collected from the same tap as the positive result. Properly identify all four samples as "repeat samples" on the sample submission forms.

Explanation of Coliform Results:
Not Detected = Coliform and E. coli bacteria were not found
Positive = Total Coliform was found and E. coli bacteria was not found
EC Positive = Coliform and E. Coli bacteria were found

The analyses performed by the EGLE Drinking Water Laboratory were conducted using methods approved by the U .S. Environmental Protection Agency in accordance with the Safe Drinking Water Act, 40 CFR parts 141-143, and other regulatory agencies as appropriate.

6.6 Certified Laboratories

All public drinking water samples required by law must be sent to a laboratory certified by the State of Michigan. Samples can be submitted to the State of Michigan Laboratory or a certified private lab. EGLE has a listing of all certified labs.

6.7 Routine Monitoring

The owner of a public drinking water supply system is responsible for making sure all required water samples are collected and reported to the LHD in a timely manner. The owner may delegate the sampling to any qualified person such as a certified operator. All procedures must be strictly followed when collecting samples and sending them in for analysis. If the sample is not taken in the proper location, if specific techniques are not followed, if the paperwork is missing information or found with inaccurate information, or if the sample is not analyzed by a state certified laboratory, the sample results will be rejected by the LHD, and enforcement actions may be taken.

The noncommunity water supply owner and operator must consult with the LHD who will determine the chemical analytes, monitoring frequencies and number of samples required for that facility. Table 6-1 shows the normal monitoring frequencies for chemical sampling. If a NCWS meets the SDWA, sampling for inorganic and organic chemicals will follow a specific compliance period as determined by the U.S. EPA.

Sampling requirements are tied to the NCWS classification, population served, water source, past sample results, vulnerability of the water supply, and results of the last sanitary survey. Reduced sampling requirements may be authorized by the LHD if a sanitary survey is conducted at least every five years and the NCWS is following the SDWA. The health department my issue a violation letter (figure 6-2) if samples are not collected on time.

Figure 6-2

EXAMPLE LETTER

RE: Monitoring Violation at System Name, Water Supply Serial Number (WSSN) WSSN

Dear Owner/Operator:

Our records show that System Name, WSSN, Source Source ID, did not submit the following water sample(s) prior to the required "collect-by" date during the monitoring period:

- Nitrate
- Cyanide
- VOC
- Lead and Copper
  - Samples taken in June, July, August, or September count towards compliance monitoring for systems on annual or 3-year monitoring as per Michigan's Safe Drinking Water Act, 1976 PA 399, as amended (Act 399), *Rule 325.10710a (4)(d)(iv)*.
- Metals
- SOC
- Arsenic
- Disinfection Byproducts (DBP)
- PFAS

Monitoring Period:

If you collected the above sample(s) during the specified monitoring period, please forward a copy of the laboratory (lab) results to my attention. If you have not already collected your sample(s), collect them immediately to avoid further monitoring violations and potential monetary fines.

A monitoring violation requires public posting be made to notify users of the failure of the public water supply to collect designated samples. The monitoring violation public notice is enclosed. Posting of the notice shall continue until sample results are received, or for a period of seven (7) days, whichever is greater.

When submitting samples, please **remember to include your WSSN**. Your WSSN is shown in the subject line at the top of this notice.

If you did collect the required sample(s) and have a copy of the lab results, contact this office as soon as possible at Phone or Email. This will allow me to change your status to "in compliance" and rescind this notice.

6.7.1 Samples Required for Transient and Nontransient Facilities

All NCWS are required to sample on a routine frequency for coliform bacteria, nitrates, and nitrites.

6.7.2 Additional Samples Required for Nontransient Facilities

NTNCWS are required to also sample for arsenic, complete metals, lead and copper, volatile organic chemicals (VOC), synthetic organic chemicals (SOC), per- and polyfluoroalkyl substances (PFAS), and cyanide on routine frequencies. On a case-by-case basis, transient water supplies may be required to sample for any of these if the LHD determines it is necessary for public health reasons.

6.8 Routine Coliform Bacteria Sampling

The SDWA requires a minimum number of coliform samples per month required per population served. NCWS operating year-round and serving fewer than 1,001 people per day shall monitor each calendar quarter that the system provides water to the public. The LHD may either increase monitoring to monthly or reduce to annually depending on compliance history and an annual site visit by the LHD. Table 6-2 summarizes the minimum samples required at most NCWS in Michigan.

Table 6-2: Routine Bacteriological Sampling Requirements

Noncommunity System using Groundwater as Source	Baseline Total Coliform Monitoring	Increased	Reduced	Notes
Year-Round Serving ≤1000 people per day	1 sample per quarter	1 per month	1 per year	Annual site visit by LHD required to qualify for reduced sampling.
Year-Round Serving between 1001 and 2500 people per day	2 samples per month	NA	NA	
Year-Round Serving between 2501 and 3300 people per day	3 samples per month	NA	NA	
Seasonal Serving ≤1000 people per day	1 sample per month while open	NA	1 per quarter	State approved Certified Start-Up Procedures. No annual option.

6.8.1 Coliform Bacteria Sample Siting Plan

NCWS shall collect samples for total coliform analysis at sites representative of the water throughout the distribution system according to a written sample siting plan that is subject to LHD review and revision. This written sample siting plan may be found in the most recent sanitary survey report from the LHD. The sample siting plan identifies the system's sample collection schedule and all sample sites, including sites for routine and repeat monitoring.

6.9 Chemical Sampling Locations

Sampling locations for each regulated contaminant are assigned by the SDWA. The specific tap or faucet the sample is to be collected is designated by the LHD in the most recent sanitary survey or other correspondence.

Some chemical samples such as lead/copper samples, are to be collected from the water distribution system. This means they are collected from drinking water taps or faucets in the building(s) served by the water supply.

Most routine chemical samples, including nitrate, nitrites, and the chemical group contaminants (VOC, SOC, PFAS, metals), are to be collected at the raw water tap or at the entry point to the distribution system.

6.10 Disinfection By-Products Rule (DBPR)

When a facility chemically feeds disinfectants to the water supply to oxidize arsenic or to kill bacteria, a "by-product" in the water may form. The EPA established the DBPR to improve public health protection by reducing exposure to these disinfection by-products (DBP) and, aims to reduce the risks associated with DBPs without increasing the risk of microbial contamination. The DBPs result from chemical reactions between chemical disinfectants and organic and inorganic compounds in source waters. Some disinfectants and disinfection by-products have been shown to cause cancer and reproductive effects in humans.

This rule requires routine sampling for DBPs. Trihalomethanes are by-products of chlorination which include chemicals that may cause cancer in humans. These by-products include chloroform, bromodichloromethane, dibromochloromethane, and bromoform. They are formed when chlorine encounters organic compounds in the water. Organic compounds primarily come from the decayed plant matter and are more likely to be found in surface water than in groundwater.

6.11 Monitoring Requirements for Surface Water Sources

The Surface Water Treatment Rule (SWTR) relates to PWS's using surface water sources or ground water sources under the direct influence of surface water. These systems are also referred to as "subpart H" systems in parts 7, 9 and 10 of the SDWA (reference to surface source filtration and monitoring).

The SWTR includes:

1. Criteria under which filtration is required and procedures by which the States are to determine which systems must install filtration; and
2. Disinfection requirements.

Pathogens, such as Giardia and Cryptosporidium, are often found in surface water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, and cramps) and other health risks. In many cases, this water needs to be filtered and disinfected using additives such as chlorine to inactivate (or kill) microbial pathogens.

Cryptosporidium is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks. Consuming water with Cryptosporidium can cause gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).

The U.S. EPA further developed the Long Term 2 Enhanced Surface Water Treatment Rule (LT2 Rule) to improve drinking water quality and provide additional protection from disease-causing microorganisms and contaminants that can form during drinking water treatment. The LT2 Rule provides a higher level of protection of the drinking water supply than the original SWTR by:

1. Targeting additional Cryptosporidium treatment requirements to higher risk systems.
2. Requiring provisions to reduce risks from uncovered finished water storage facilities.
3. Providing provisions to ensure that systems maintain microbial protection as they take steps to reduce the formation of disinfection by-products.

This combination of steps, combined with the existing regulations, is designed to provide protection from microbial pathogens while simultaneously minimizing health risks to the population from disinfection by-products.

6.12 Records Retention

A supplier of a Noncommunity water system shall retain, on its premises or at a convenient location near its premises certain records and documents for a prescribed amount of time according to the SDWA Rule 1506. These records include items such as: bacteriological and chemical sample results; records of action taken by the supplier to correct violations of the state drinking water standards; copies of any written reports, summaries, or communications which relate to sanitary surveys of the public water supply and which were conducted by the public water supply itself, by a private consultant, by the division, or by any local, state, or federal agency; records that involve a variance or an exemption that was granted; records that involve any emergency or public notification; and systems that employ conventional filtration or direct filtration treatment must retain certain filter and flow information.

Table 6-3: Retention of Records

Record to Retain	Time to Keep (not less than)
Bacteriological analysis	5 years
Chemical analysis	10 years
Radiological analysis	10 years
Lead/copper corrosion control papers	12 years
Action taken to correct violations	3 years after last action taken
Sanitary surveys	10 years
Variances or exemptions	5 years (after expiration date of either)
Emergency or public notices	3 years (after emergency or public notice)

6.13 Response to Coliform Detections

In 2016, Michigan adopted a revision to the 1989 Total Coliform Rule intended to improve public health protection. It became effective April 1, 2016. The Revised Total Coliform Rule (RTCR) establishes a maximum contaminant level (MCL) for *E. coli* and uses *E. coli* and total coliforms to initiate a "find and fix" approach to address contamination that could enter the distribution system. NCWS are required to perform assessments to identify sanitary defects and subsequently act to correct them.

When water sample results are positive for coliform bacteria (at levels of 1 per 100ml of water or greater), the water may also contain pathogens that cause acute intestinal infections. While generally considered to be a discomfort to health, these infections can prove fatal for infants, the elderly and those who are immunosuppressed.

The presence of *E. coli* or fecal coliform is a more serious situation than the presence of total coliform alone. *E. coli* or fecal coliform presence indicates that human or animal fecal material has contaminated the water system and any ingestion of this water poses a serious health threat. The water must not be consumed in any way. The public water system needs to act promptly, notify the public, restrict the use of water, and provide an alternative water supply until the problem is corrected.

6.13.1 Repeat Coliform Bacteria Sampling

Upon receiving a total coliform or *E. coli* positive water sample result, it is the responsibility of the NCWS to comply with the repeat sample requirements. If a routine sample is total coliform-positive, the water supply owner or certified operator must collect a set of repeat samples within 24 hours of being notified of the positive result pursuant to the sample siting plan provided by the LHD.

As directed by the sample siting plan, one of the four (4) samples must be from the same sample tap as the original positive sample. Two (2) additional samples shall be from the distribution system within five (5) service connections (upstream and downstream) from the positive result. Additional samples must be collected at the raw water tap often located near the well's storage/pressure tank for each well. If a NCWS does not have faucets that meet these criteria, the LHD will create a sample siting plan that best meets the intent of the rule. These samples are to be labeled as "repeat" samples on the laboratory form. Failure to collect the required repeats in a timely manner triggers a Level 1 Assessment.

For systems on either annual or quarterly monitoring for total coliform, three (3) additional routine samples are required to be collected in the month following the initial positive sample. These samples should be labeled as "routine" samples on the laboratory form. These samples should also follow the sample siting plan. The three (3) additional routine samples cannot be collected from the same faucet on the same day.

6.13.2 Disinfecting After a Single Positive

Facilities that disinfect their water supply system after a single positive coliform sample may be in violation if they do not collect repeat samples within 24 hours of notification of a positive result. The system must be flushed until all chlorine residual is absent and four (4) repeat samples collected before resuming operation.

The well disinfection procedure must be performed by a Michigan registered water well driller, pump installer, or a Michigan licensed master plumber. Owners and operators of NCWS are not authorized under Part 127 of Act 368, Ground Water Quality Control, to chemically treat a well.

6.13.3 *E. coli* MCL Violation

An acute *E. coli* MCL violation occurs with any of these sampling set combinations:

Table 6-4: *E. coli* MCL Violations

Routine Sample	Repeat Sample
E. coli positive	Total coliform positive
E. coli positive	Any missed repeat sample
Total coliform positive	*E. coli* positive
Total coliform positive	Total coliform positive (no *E. coli* analyzed)

Contact your LHD and initiate an investigation (Level 2 Assessment) to determine the extent of the problem, which may include the collection of additional samples. The water must not be consumed in any way. Water users should be aware of potential consumption risk through food preparation, making ice, brushing teeth, and washing dishes. Initiate precautionary measures and appropriate corrective actions as required by the LHD until it is determined that the problem has been resolved.

The owner is required to post notice provided by the LHD with required language where water is consumed. Parents/guardians are to be notified if consumers are children. The notice will list the restrictions on use of water as appropriate. A copy of signed notice shall be returned to LHD for verification. If there is a licensing agency responsible for overseeing the system, the agency must be notified.

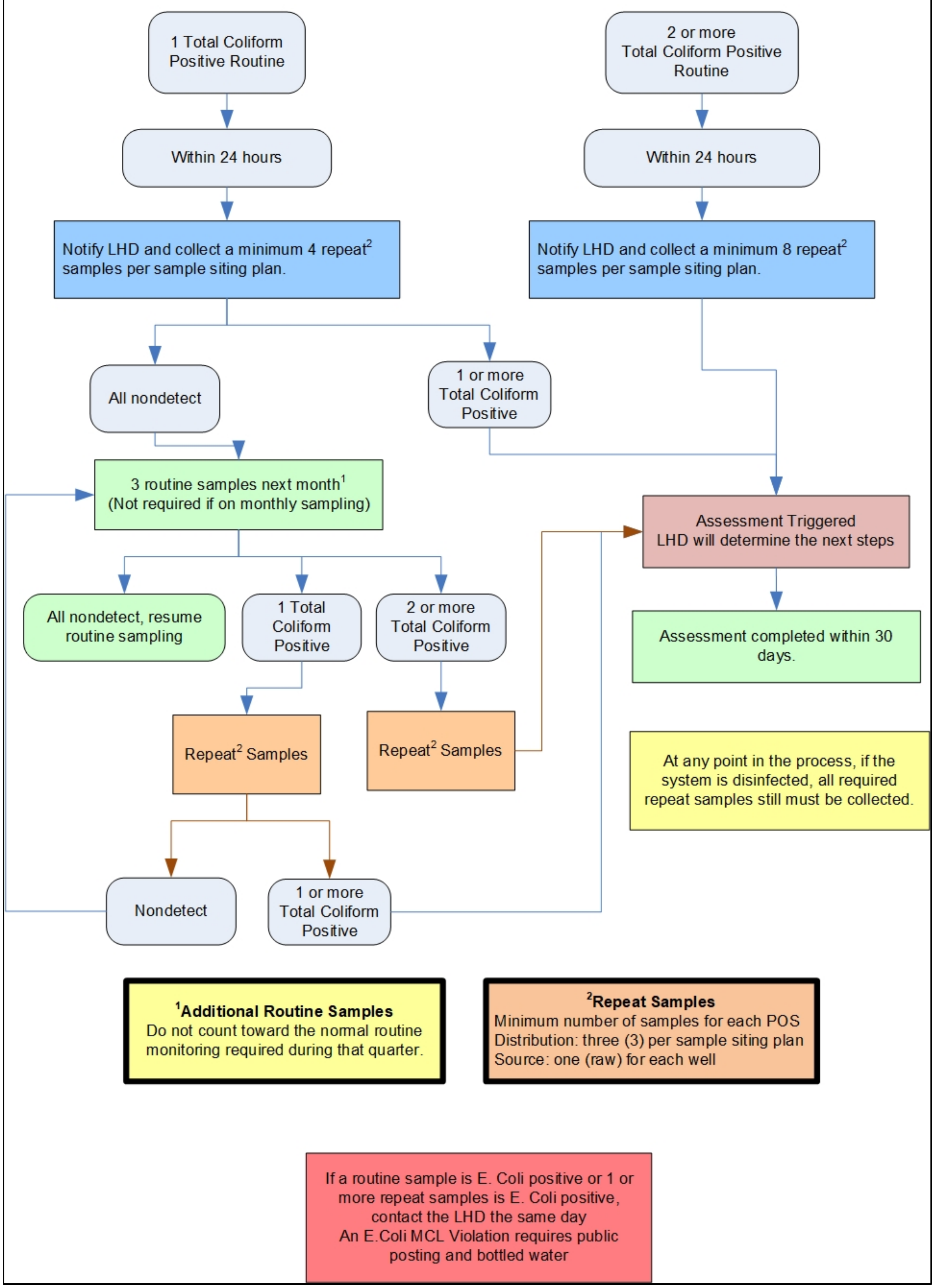
If the facility is to remain open, an approved alternate source of water (typically bottled water) must be provided by the NCWS for potable use as indicated in the public notice. Additional measures may be necessary including providing alternate means of hand washing, suspension of food preparation, etc. If the LHD determines the continued operation would put public health at risk, closure can be ordered.

As a result of an *E. coli* MCL, the NCWS will automatically revert to monthly total coliform monitoring. The LHD will reevaluate the water supply after 12 months to see if reduction in monitoring is appropriate.

Figure 6-3

Revised Total Coliform Rule

Response Flowchart for Total Coliform Positive



6.14 Level 1 and Level 2 Assessments

The RTCR includes requirements to investigate a water system and correct sanitary defects when monitoring results show the system may be vulnerable to contamination. Assessments are required to be conducted following unsafe sample results or failure to collect repeat samples. An assessment of the water supply includes an evaluation of the following:

- Unusual occurrences prior to sampling
- Changes to the water system
- Sample site/sampling protocol
- Wellhead
- Treatment process, if applicable
- Pressure tank
- Distribution system

A Level 1 Assessment (LV1) is a basic evaluation of the water supply, which may be completed by the LHD, well owner, or drinking water operator and is triggered by the following:

- Failure to collect all four (4) repeat samples
- Two (2) or more total coliform positive samples in the same month

A Level 2 Assessment (LV2) is comprehensive evaluation of the water supply completed by the LHD and is triggered by the following:

- An *E. coli* MCL
- Second LV1 in 12 months for supplies on quarterly monitoring
- LV1 triggered in two (2) consecutive years for supplies on annual monitoring

6.15 Follow-up Monitoring and Corrective Action

When a contaminant is found in the drinking water, additional monitoring may be required. If the follow-up monitoring indicates that a contaminant exceeds the established MCL, the NCWS will be required to take corrective actions. The LHD should be contacted immediately by the owner/operator for consultation. The NCWS may be required to provide an alternate source of drinking water to the public until the supply is known to be safe.

Chapter 7

Public Notification (PN)

If a NCWS fails to meet or comply with requirements regarding an applicable MCL, it must notify the public and provide an alternate source of safe drinking water until the problem has been corrected.

A Public Notice warns all potential users of the water supply that the water has been found to be in violation of the SDWA. The notice must include possible health effects from consuming the water and the location where safe water is available if the system is required to provide an alternate source of water. For many NCWS, an acceptable method of providing public notification is to post warning signs at all potential drinking water taps or at the entrance to the facility.

Specific health effects language is required on the public notice. The LHD staff will have the appropriate notice for the contaminant with the MCL.

Public Notices must remain in place for as long as the violation or situation exists, but not for less than seven (7) days, even if the violation or situation is resolved.

7.1 Timing and Distribution

NCWS owners/operators must notify persons using the water AND the LHD staff working as the noncommunity program coordinator within 24 hours when notified of the violation. Immediate action to do what is needed to prevent consumption of the water and notification of the public by posting a Public Notice at all water outlets that may be used for consumption is required to protect public health.

Immediate posting of a public notice is required for the following violations:

- Fecal coliform
- Nitrate
- Chlorine dioxide
- Turbidity
- Waterborne disease outbreak or another waterborne emergency
- MCL violations
- Monitoring violations
- Other violations or situations determined by the LHD

Public Notices are also required when an MCL occurs, the failure to collect the proper water quality samples on time (monitoring violations) and treatment technique violations occur. The LHD may also require a public notice upon failure to comply with variance and exemption conditions.

7.2 Contents of a Public Notice

Unless otherwise specified in the regulations, each notice must contain:

- A description of the violation including contaminant levels
- When the violation occurred
- Any potential adverse health effects (use language from SDWA public notification rule 405)
- The population at risk
- Whether alternative water supplies should be used (or bottled water)
- What actions consumers should take
- What the system is doing to correct the violation
- When the water system expects to return to compliance or resolve the issue
- The name, business address, and phone number of the water system owner or operator
- A statement encouraging distribution of the notice to others, where applicable.

Figure 6-4: Example E. coli MCL Public Notice

E. coli bacteria were found in the NAME OF SYSTEM water supply on DATE.

DO NOT DRINK THE WATER.
USE ALTERNATE SUPPLY OF WATER FOR CONSUMPTION AND OTHER USES AS NOTED

Potential Health Effects
E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Human pathogens in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a greater health risk for infants, young children, the elderly, and people with severely-compromised immune systems.

The symptoms above are not caused only by organisms in drinking water. If you experience any of these symptoms and they persist, you may want to seek medical advice. People at increased risk should seek advice about drinking water from their health care providers. Use commercially prepared hand sanitizer/wipes for hand washing. Do not allow infants or young children to bathe or shower in contaminated water since they may ingest it.

What happened and what is being done

Bacterial contamination can occur when surface waters gains entry to the drinking water source, storage or distribution system (after construction, repairs, or damage to the well, tanks or piping).

We are working with the local health department to resolve this problem. We anticipate resolving the problem within ESTIMATED TIME FRAME. For more information, please contact NAME / PHONE / ADDRESS or the LHD Name.

PROOF OF DELIVERY

I certify that this water supply has fully complied with the public notification requirements in the Michigan Safe Drinking Water Act, 1976 PA 399, as amended, and the administrative rules.

Signature	Title	Date Distributed

Chapter 8

Groundwater Well Construction

Most water systems in Michigan have a well or wells to meet their water use needs. A basic understanding of drinking water well construction is essential for the operation and maintenance of the drinking water supply as well as protection of the source water and public health. This section refers to water supply wells, or wells that are used to provide potable water for drinking or domestic purposes. Visit the EGLE well construction website for more information at: Michigan.gov/EGLE/0,9429,7-135-3313_3675_3694---,00.html.

To get the water out of the ground, there must be some method or device to do so. A well is a structure designed to withdraw water from the ground and is either a “drift” or “rock” well depending on what type of formation the casing terminates in. Because there is a direct opening from the surface down into the groundwater, it is of utmost concern to construct and maintain the well properly, so the source water is not polluted. Cleaning up a contaminated groundwater supply may be costly, complicated, and sometimes impossible to do therefore, the best way to guarantee clean and safe groundwater is to prevent contamination.

Safety of groundwater depends on:

- ✓ Proper Selection of the well site
- ✓ Good well design and construction
- ✓ Geology

Depending on the depth to groundwater, the amount of water needed, and the water quality, wells can range from a few feet to thousands of feet deep. The methods used for constructing wells are dug, driven, and drilled. A permit must be issued by the LHD before the construction or alteration of any waterworks system can begin.

8.1 Formations

A “drift” well terminates in a layer of water bearing sand and gravel, requires a screen to keep the sand out of the well and may include gravel pack around screen to increase capacity.

A “rock” well terminates in porous, water bearing limestone or sandstone, water enters the well through an open borehole below the casing and no well screen is required.

8.2 Drilled Wells

Most wells in Michigan are constructed using a drilling method. Drilled wells are typically done with a “Cable Tool” well rig or a “Rotary” well rig. The rotary method involves drilling a hole, installing steel or plastic casing, and grouting around the casing to prevent entry of contaminants into the groundwater. A properly constructed drilled well provides good protection of the water supply source.

Image 8-1

The picture to the left is a submersible well with a plastic casing. The gray material is grout, which seals the opening between the ground and the casing. The electrical conduit holds the electrical wires from the power supply to the submersible pump. For safety purposes, the electrical conduit must be gray in color for identification between electrical conduit and plastic water pipe, which is white in color. The conduit must also be tightly sealed to prevent a shock hazard and contaminants from getting down into the well casing.

8.3 Water Well Record

The water well and pump record is prepared by the driller and given to the well owner when the well is completed. In addition to address and well location information, the well record describes each geologic stratum encountered, the various depth(s) where water was encountered, and the overall depth of the well. It also lists construction details such as casing type and size, perforation type and depth, screens used, grout and sealing methods, etc. Careful study will also reveal static water level, test pump rates, and drawdown. Interpretation of the data will help to determine whether the well is in a confined or unconfined aquifer, what the maximum pumping rate of the well should be, and other useful information.

The well record should be kept on file at the facility. If the facility does not have a record, they could contact the well driller. If a well log cannot be found, have the well evaluated for static water level, depth of casing and total depth of well the next time the pump is replaced, or work is done on the well (i.e., bulk chlorination).

Well information is entered into a statewide database and each well record is given a unique identification number (Well ID). An example Wellogic well record is show as Figure 8-1.

Figure 8-1

EGLE

Water Well And Pump Record

Completion is required under authority of Part 127 Act 368 PA 1978.
Failure to comply is a misdemeanor.

Wellogic

Import ID:

Tax No: | **Permit No:** | **County:** Ottawa | **Township:** Robinson

Town/Range: 07N 15W | **Section:** 22 | **Well Status:** Active | **WSSN:** 2008270 | **Source ID/Well No:** 001

Well ID: 70000003162

Elevation: 623 ft.
Latitude: 42.98256
Longitude: -86.0832
Method of Collection: GPS Std Positioning Svc SA Off

Distance and Direction from Road Intersection: on SE corner of 120th and Pingree

Well Owner: St. John's Luthern Church

Well Address: 11790 120th, Grand Haven, MI 49417

Owner Address: 11790 120th, Grand Haven, MI 49417

Drilling Method: Rotary
Well Depth: 32.00 ft. **Well Use:** Type II public
Well Type: Replacement **Date Completed:** 2/2/1995
Casing Type: PVC plastic **Height:**
Casing Joint: Welded
Casing Fitting: None
Diameter: 5.00 in. to 27.00 ft. depth
Borehole: 8.00 in. to 27.00 ft. depth

Pump Installed: Yes **Pump Installation Only:** No
Pump Installation Date: **HP:** 0.50
Manufacturer: F.E. Myers **Pump Type:** Submersible
Model Number: **Pump Capacity:** 12 GPM
Drop Pipe Length: 20.00 ft. **Pump Voltage:**
Drop Pipe Diameter: 1.25 in. **Drilling Record ID:**
Draw Down Seal Used: No
Pressure Tank Installed: Yes
Pressure Tank Type: Diaphragm/bladder
Manufacturer: Well-Mate
Model Number: 12 **Tank Capacity:** 12.0 Gallons
Pressure Relief Valve Installed: No

Static Water Level: 5.00 ft. Below Grade
Well Yield Test: **Yield Test Method:** Air
Pumping level 0.00 ft. after 0.00 hrs. at 20 GPM

Formation Description	Thickness	Depth to Bottom
Sand	32.00	32.00

Screen Installed: Yes **Filter Packed:** No
Screen Diameter: 5.00 in. **Blank:**
Screen Material Type: PVC-saw cut

Slot	Length	Set Between
10.00	5.00 ft.	27.00 ft. and 32.00 ft.

Fittings: None

Well Grouted: Yes **Grouting Method:** Grout pipe outside casing

Grouting Material	Bags	Additives	Depth
Neat cement	12.00	None	0.00 ft. to 25.00 ft.

Geology Remarks:

Wellhead Completion: Pitless adapter, Other, 12 inches above grade

Nearest Source of Possible Contamination:

Type	Distance	Direction
None		

Drilling Machine Operator Name: Jeff DeWind
Employment: Employee

Abandoned Well Plugged: Yes

Casing Removed:

Contractor Type: Water Well Drilling Contractor **Reg No:** 70-1922
Business Name: DeWind Drilling
Business Address: 9594 ort Sheldon, Zeeland, MI, 49464

Water Well Contractor's Certification

This well was drilled under my supervision and this report is true to the best of my knowledge and belief.

Signature of Registered Contractor **Date**

General Remarks:
Other Remarks:

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8.4 Common Well Terminology

8.4.1 Static Water Level

Static water level is measured as the level water is standing in a well when no water is being removed from the aquifer.

8.4.2 Drawdown

Drawdown is a drop in the water table or groundwater when pumping is being pumped from a well. Drawdown is determined by the ability of the aquifer to replace the amount of water that is being pumped from the well. If there is an abundance of water in an aquifer and the water can move freely to the well, the drawdown will be low, typical of sand, gravel, and bedrock formations. Conversely, if the water cannot move through the formation quickly enough to replace the water being pumped, the drawdown can be quite high.

8.4.3 Pumping Water Level

The pumping water level is where water stands in the well when pumping is in progress. The pumping water level is an indication of the amount of water that can be safely removed from the aquifer.

8.4.4 Cone of Depression

The cone of depression is a conical depression, around the well casing, of the water table produced when pumping occurs. The cone of depression defines the area of influence of a well and how far the well needs to be away from potential sources of contamination. It varies in size and shape depending on pumping rate, duration, aquifer characteristics, recharge conditions, etc.

8.4.5 Well Yield

Well yield is commonly referred to as the gallons of water that can be pumped per minute from the aquifer.

8.4.6 Specific Capacity

The specific capacity of a well is the rate of water that discharges from a well per unit of drawdown (usually feet). It is typically measured after 24 hours of pumping. The specific capacity decreases as pumping increases or pumping time increases. By tracking the specific capacity of a well over time, an operator can identify well and aquifer performance problems.

8.4.7 Well Abandonment

The SDWA, refers to Part 127, of Act 1978 PA 368, Groundwater Quality Control Rules, for regulations of the abandonment of any well which; has its use permanently discontinued, is in such disrepair that its continued use for the purpose of obtaining groundwater is impractical, which has been left uncompleted, which is a threat to groundwater resources, or which is or may be a health or safety hazard.

8.4.8 Well Disinfection

Well disinfection is an important part of providing safe drinking water. If not done correctly, it is simply a waste of time and money. Michigan has specific rules for licensed well drillers to follow. Disinfection of a noncommunity drinking water well must be completed only by a licensed well driller, pump installer, or Master Plumber.

Disinfection of a newly constructed well is required by the Well Construction Code. Disinfection of the well and distribution system is required if any repair work is done. Shock disinfection may also be utilized if a bacteriological contamination is encountered. You must contact your LHD before disinfection of a noncommunity public water well and the well disinfection process must be done by a Michigan registered water well driller.

Chapter 9

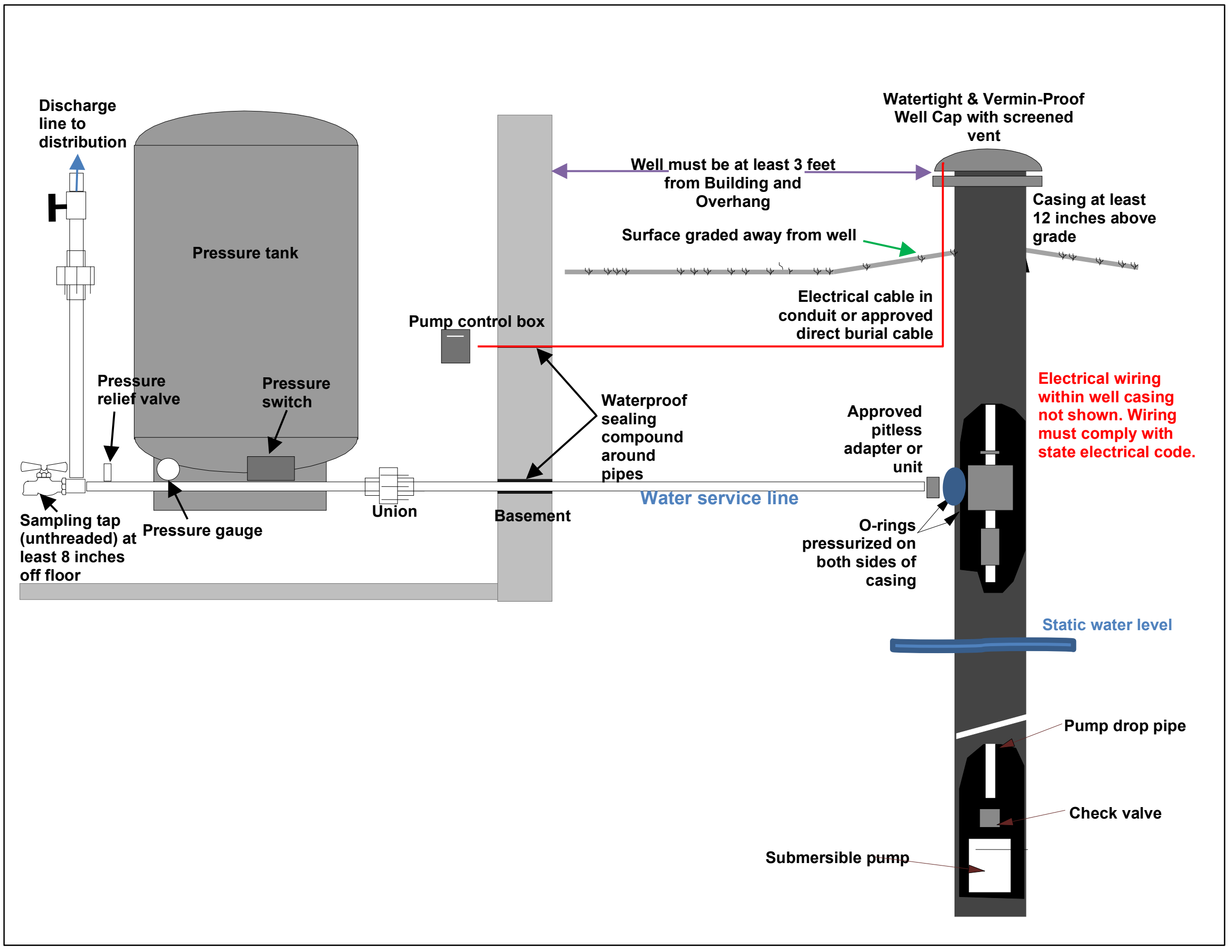
Water Supply Equipment

The water supply system may be divided into the water source, (groundwater or surface water), the well and pump for groundwater sources or water intake structures for surface water sources, storage facilities, treatment facilities and the distribution system (the pipes which deliver water to consumers). If the water supply system and equipment are not being operated effectively and reliably, or if the equipment does not meet construction standards, the water served to consumers may not be pleasant tasting, safe to drink, or an adequate amount of water and pressure may not be available.

9.1 Equipment Standards

Water supply equipment must meet the Michigan Plumbing Code regulations and standards. Some examples of agencies that approve equipment standards are: The American National Standards Institute (ANSI); American Society of Mechanical Engineers (ASME); American Society of Sanitary Engineering (ASSE); ASTM International (ASTM); and NSF. Products that contact water must be NSF 61 certified and chemicals injected into water supply must have NSF 60 certification.

Figure 9-1: Typical Well System Installation



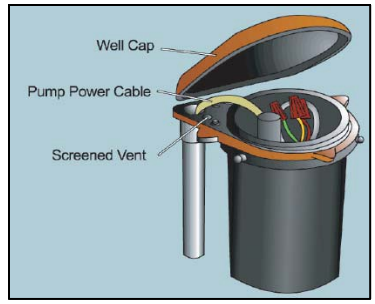
9.2 Water Well Components

Properly designed and constructed wells minimize the risk of well water pollution by sealing the well from anything that might enter from the surface. The most common well pumps in use are called "submersible." They are powered by electricity and push the water up to the surface. In any area where there is frost, the water pipe comes from the well through a pitless adapter below ground level. In warmer climates there is no need to use a pitless adapter, the water pipe can come out of the top of the well.

9.2.1 Well Casing

The casing is a steel or plastic pipe installed during construction to prevent collapse of the borehole. It provides a connection to the groundwater and a pathway for bringing the water to the surface. The annulus space between the casing and sides of the hole must be sealed with grout to prevent pollutant seepage into the well along the well casing. The casing must terminate at least 12 inches above the ground surface or floor of a well house and the ground surface around the casing must be sloped away to prevent liquids from accumulating around the well, which may cause contamination of the groundwater.

Figure 9-2



9.2.2 Well Cap

A well cap (figure 9-2) should be weatherproof and tightly sealed with a down turned and screened vent to prevent well contamination from dust, debris, insects, rodents, and bird droppings. The vent allows air to enter the well during drawdown to prevent vacuum conditions.

9.2.3 Electrical Conduit

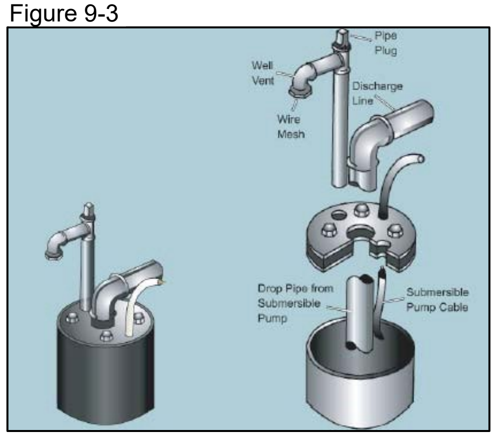
The electrical cable or wiring on the outside of the casing shall be protected by a rigid conduit from the well cap/seal to a point below grade. The rigid conduit must be securely attached to the well cap/seal and must extend below grade to the minimum depth required for the cable (18 inches below the ground surface). The conduit must be provided with an electrical bushing or fitting at the point where the cable enters and leaves the conduit. This bushing or fitting protects against cable damage due to abrasion. Types of conduits approved for submersible pump installations are rigid metal conduit (galvanized) or a rigid nonmetallic conduit which must be grey (color designated for electrical components), PVC plastic, and schedule 40 or 80. Conduit helps prevent contaminants (insects, mice, etc.) from getting into the well.

Black polyethylene (P.E.) pipe/tubing is not an approved electrical conduit material (MDPH Well Words. Division of Water Supply – Ground Water Quality Control Chapter. Vol.14 No.1. Feb 1994, page 8.).

9.2.4 Sanitary Well Seal

A sanitary well seal (figure 9-3) is used instead of a well cap on wells that have piping exiting at the top of the casing. It consists of a rubber gasket that is sandwiched between an upper and lower metal plate that all fits inside the top of the casing. The sanitary well seal has openings on the top for piping. Two-piece top plate sanitary seals are only acceptable for wells located in an approved well house. (Minnesota Dept. of Health, 2002).

Figure 9-3



9.2.5 Pitless Units and Adapter

A pitless adaptor or pitless unit is used to create a frost proof connection between the well and the water service line. The water service line is attached to the fittings on the well underground, below the frost line to prevent freezing during cold weather. The water service line connects the well to the water distribution system.

9.2.6 Check Valve

The check valve is used to prevent water from flowing back down into the well when the pump has been shut off. If the check valve fails, the water flowing back down into the well will stir up the geological formation, which may cause silt, sand, or other materials to be present in the drinking water. (Minnesota Dept. of Health, Safe Drinking Water for Your Small Water System, 2000.)

9.2.7 Water Service Line

The water service line is the water pipe that delivers the water from the well to the buildings being served.

9.3 Pumps

There are different types of pumps that force the water up from the groundwater to the distribution system. The most common types used in noncommunity systems are the submersible pump, jet pump and hand pump.

Submersible Pump – is designed to operate completely submerged under water in the well casing.

Jet Pump – is located on top of the well casing or offset from the well in a pump house or basement. It is connected to the well with piping and operates by forcing water through a jet or venturi, which creates a partial vacuum (suction) and draws water from the well into the pumping system.

Hand Pump – this consists of a cylinder on a pump rod, which moves up and down and forces water to the surface. They are commonly found in parks and other recreational settings.

Well Screen
Well screens are used in drift wells and in some rock wells. The purpose of a screen is to prevent sediment from entering the well while allowing water to enter the well. The slot sizes on screens vary according to how “fine” or “coarse” the sand and gravel material at the bottom of the casing are.

Raw Water Sample Tap
A raw water sample tap allows for the collection of a water sample prior to any treatment that a facility may have. It is also used to test the quality of the well water itself. An approved tap should have a small diameter outlet in an accessible location at the pressure tank or as near to the well as possible. The spout is to be at least 8 inches above the floor, with no threads on the end and downturned. The raw water sample should be collected after the pump kicks on to ensure you are getting water from the source, and not the distribution system.

9.4 Water Storage and Pressure Tanks

The main purpose for water storage is to provide enough water for the daily demands so the pump does not have to operate every time the faucet is turned on and to help maintain adequate pressure throughout the distribution system. Water storage must also provide water for peak demands, which is the time of the day when the water is used the most (such as during lunch time, or when children are showering after gym class).

Other purposes of water storage may include meeting the needs for fire protection and industrial use. The major types of tanks are hydropneumatic (diaphragm or bladder), elevated storage, and ground storage tanks. Hydropneumatic pressure tanks can be used very successfully in well pump operations to maintain adequate pressure throughout distribution systems.

Types of Storage Units

There are three major types of storage tanks, however only pressure tanks will be described as they are the type typically seen at noncommunity public water systems:

- Pressure Tanks
- Elevated Storage Tanks
- Ground Storage Tanks

9.4.1 Pressure Tanks

These tanks can range in size from small household units to much larger industrial/institutional sizes. A pressure tank may be designed with or without a bladder that separates air and water in the tank (figure 9-4).

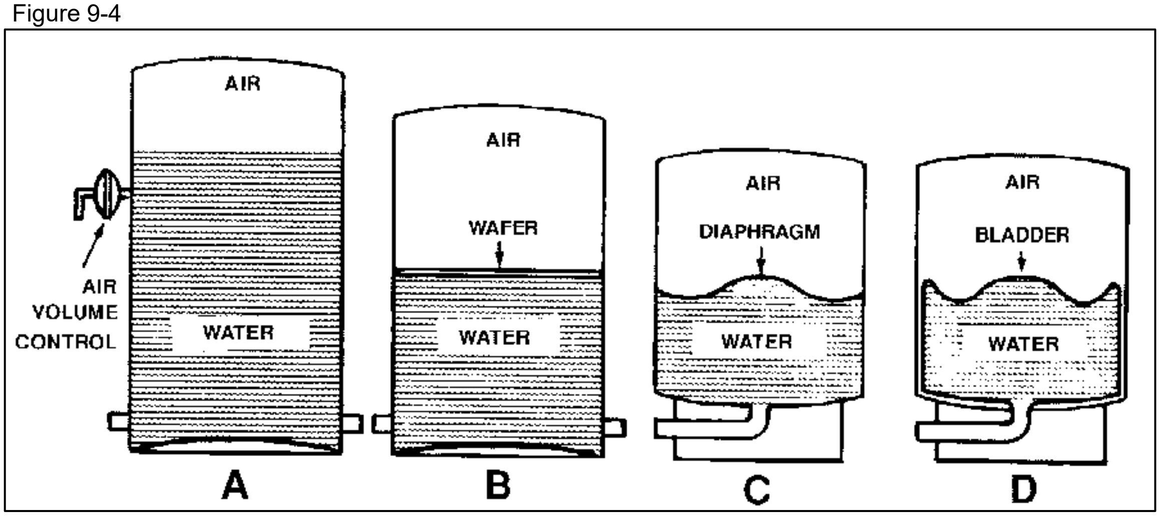
9.4.2 Air-to Water (No Bladder) Pressure Tanks

These tanks operate using a pressure-rated tank containing approximately two-thirds water and one-third air at full capacity. These tanks do not have a barrier between the water and air in the tank and may become "water-logged" if the air leaks out or is absorbed by the water. An air compressor is periodically used to replenish the air in the tank.

9.4.3 Bladder (Diaphragm) Pressure Tanks

This type of tank uses a bladder, or diaphragm, as a flexible separator between the air and water in the tank. The bladder prevents loss of air to the water thus eliminates the need for an air compressor. Very small tanks do not provide much storage but provide pressure and prevent excess pump cycling.

Figure 9-4



Key to Figure 9-4:

A. Galvanized (steel) water storage tank
B. Galvanized tank with a wafer separating the air from water = less mixing of water molecules into air
C. Pressure tank
D. Bladder pressure tank

9.4.4 Tank Routine Maintenance

Routine maintenance includes observing the pressure gauges to verify proper operation of the pressure tank. Typically, operating pressures are between 40 and 60 pounds per square inch (psi). A well pump installer will set the operating pressure when the water equipment is initially installed.

The tank storage room should be adequately vented to reduce the external corrosion of the tank which may be brought on by excess moisture. Tanks that lose air pressure and become water-logged must be repaired or replaced as the pressure is minimized and the pump runs whenever there is water demand. These tanks should be kept in a heated building to prevent freezing and should never be operated above the pressure rating of the tank shown on the manufacturer’s plate. Tanks should also be equipped with a pressure relief valve.

Chapter 10

Water Distribution System

The distribution system consists of a network of pipes, valves, storage tanks, fire protection pipes, service lines, meters, and other appurtenances. Pipes transport or "distribute" the water throughout the facility and valves are needed to isolate portions of the system for cleaning, maintenance, repairs or adding on to the system. The service line is the piping that connects the source water to the building or the water supply from one building to another. It is critical that the distribution system is properly maintained and free of cross connections with unapproved water supplies that could allow contamination to be introduced into the drinking water system. Continuous positive water pressure in the system under all conditions is critical to protect the distribution system from the entrance of contaminants.

Improper installment of new water treatment equipment, other distribution system appurtenances, or piping may result in contamination of the distribution system water. Repair or replacement of leaking pipes without using approved materials or proper disinfection of the system after the work is done can also lead to water quality problems.

10.1 Distribution Pipe

Piping used to transport drinking water throughout the system must be of approved materials and sizes to deliver safe and enough water to the consumer. Pipe materials must meet the minimum requirements of the Michigan Plumbing Code for drinking water. Plastic, copper, ductile iron, and steel pipe are commonly used for exterior water service lines. Plastic pipe must be marked with NSF-pw indicating that it is safe for carrying potable water.

Water distribution piping in buildings is usually copper or plastic with some old piping consisting of galvanized steel. Today, copper pipe must be jointed with lead free solder. Polyethylene pipe (flexible black pipe) is not approved for use as distribution piping.

10.2 Meters

The primary function of a water meter is to measure the amount of water passing through it and provides many benefits to the water operator. A meter assists in informing the operator of water losses somewhere in the distribution system, of potential system problems, of exactly how much water is being used (or wasted), and to help determine when backwashing or filter media needs to be changed when certain water treatment devices are used. With proper operation, maintenance and monitoring of the water meter, a facility may be able to save money by heading off problems.

10.3 Valves

Valves should be installed at enough points throughout the water system to provide adequate isolations during repairs. Valves should be "exercised" or turned on a regular basis to ensure that they will work properly when needed. Some common valves are gate valves, ball valves, and globe valves.

10.4 Water Equipment Contamination

If equipment in a distribution system, such as storage tanks, water heaters, treatment devices, is not being operated effectively and reliably, contaminants can build up and be passed into the distribution piping. For example, a chlorinator not properly operated or maintained could result in pathogenic organisms entering the distribution system.

10.5 Cross Connections

An unprotected connection between any part of a drinking water system and any source or system containing water or a substance that is not or cannot be approved as safe, wholesome, and potable for human consumption could result in the delivery of contaminated water to consumers. It is imperative for the operator to constantly monitor the system in the prevention of cross connections (refer to the Cross-Connection Chapter in this Guide for more detailed information).

10.6 Corrosion

Corrosion is the gradual deterioration or destruction of a substance or material by chemical action proceeding inward from the surface. Corrosion of metal may occur either on the inside or outside of the surface and many factors influence the rate of corrosion such as water temperature, water velocity, if two different metals come in contact, and specific substances in the water. For example, higher water temperature, dissolved minerals, dissolved oxygen, and sulfate-reducing bacteria can speed up corrosion. Carbon dioxide in the water lowers the pH of water making it more corrosive. Monitoring for lead, copper, zinc, etc., in the water will inform the operator whether elevated levels are present that may cause future problems.

10.6.1 Seasonal Temperatures

The temperature of water has three major impacts on water quality. Higher temperatures speed the rate of chemical reactions and increase biological growth. Summer temperatures may intensify biological decomposition and require greater chlorine demand if a system is disinfecting the distribution lines.

10.6.2 Water Flow Rate

Changes in the flow rate of water through the distribution system could result in sediments being stirred up and stagnant water, both causing water quality problems. Continuous positive system pressure is necessary to prevent contaminants from entering the drinking water system.

10.7 Dead Ends

Dead end piping in the distribution system may cause major water quality problems since the water flow is very low, the time of contact of water with the pipe and any deposits, encrustations, or slimes is long, there may be an accumulation of organic matter containing nutrients which is a food source for bacteria, and there is low oxygen which may produce carbon dioxide, methane, and foul sulfide odors. Therefore, dead ends should be eliminated if possible.

10.8 Operation and Maintenance

Poorly performed water quality monitoring, failure to adequately flush the water system, insufficient surveillance of equipment, inadequate cross connection control, improper disinfection practices, disregard of hazards and threats to the water system, and lack of trained operators all contribute to potential water quality problems. As water supply system equipment and piping become older, more maintenance is required, and more water quality problems may arise.

Chapter 11

Limited Treatment

This chapter is important for certified operators who operate limited treatment or complete treatment facilities (D-5 or F-5 levels). However, a distribution system operator not treating to meet drinking water standards or not adding chemicals to drinking water may want to review the information on water softener units.

Most groundwater sources in Michigan provide quality water that meets federal drinking water standards. However, if the drinking water source is from surface water or a groundwater source that contains contaminants that pose a health risk, continuous treatment to remove the contaminants is necessary. If treatment for water quality purposes is required, persons responsible for the operation of the public water system must be knowledgeable in the operation, maintenance, and procedures involved in adding chemicals to the water, and must demonstrate this knowledge by passing an operator certification examination. Treatment may also be used to improve the water's aesthetic characteristics such as reducing hardness or iron content.

11.1 Taste and Odor Control Methods

Taste and odor problems in drinking water may be seasonal, occasional, infrequent, or persistent and complaints from consumers will vary depending on the individual's sight, smell, and taste. Many substances causing objectionable taste, color, or odor in drinking water are considered secondary contaminants and are not required by law to be monitored and removed; however, to get consumers to drink the water, treatment may be warranted. Taste and odors can be the result of natural or manmade conditions that exist in the source water or anywhere in the water supply system. Some natural causes include biological growths or minerals and chemicals in the environment. Some man-made causes include municipal and residential wastewater, industrial wastes, chemical spills, agricultural wastes, and urban runoff.

Some methods of treatment for taste and odor include many of the below mentioned treatments as well as aeration, oxidative, and adsorption processes. The owner or certified operator must contact the LHD before the installation of any type of treatment, even though it might be for aesthetic reasons. A permit, evaluation and approval may be needed.

11.2 Water Softening

Hard water is generally considered to be that which requires considerable amounts of soap to produce a foam or lather and that also produces scale in hot water pipes, heaters, boilers, and other units in which the temperature of water is increased. Hard water is often the cause of excessive calcium and/or magnesium in the groundwater. Noncommunity water systems that use a water softener to remove water hardness for aesthetic reasons are not required to have a D-5 level certified operator, however, use of ion exchange for removing a primary drinking water standard component will require a D-5 certified operator.

The ion (an electrically charged atom) exchange treatment process involves passing water through a media that can exchange cations (positively charged ion). As water passes over the media, non-hardness causing cations attached to the media are exchanged with hardness causing (calcium and magnesium) cations present in the water. This exchange continues until the media has been exhausted. The exhausted media is then regenerated, and the softening process begins again.

The media is typically an artificial resin and the non-hardness exchange cation most used is sodium since it can be obtained at low cost from common salt.

11.2.1 Operation of a Water Softener

Most ion exchange softeners operate as pressurized systems with a downward flow of water through the exchange resin (media). The water enters the unit through an inlet distributor at the top, is forced by pressure through the exchange media where the hardness ions are exchanged for sodium ions, then flows into an under-drain structure and out to the distribution system. Water leaving the softener contains nearly zero hardness. Such water is corrosive and aesthetically objectionable. In general practice, a portion of the raw water is bypassed to provide a blend of softened water and unsoftened water. The amount of water bypassed is typically adjusted so that the water entering the distribution system has a total hardness between 80 to 100 mg/L.

The ion exchange process continues automatically until the supply of sodium ions in the resin is almost depleted. When this occurs, increasing numbers of hardness ions pass through the bed, unremoved, and the softener resin is termed "exhausted."

11.2.2 Backwashing a Water Softener

Once the softener is exhausted, the unit must be taken out of service to clean and regenerate the resin which is accomplished in a three-stage process.

Stage One

Water is reversed through the unit to loosen the resin and clean it. This takes approximately 5 – 10 minutes.

Stage Two

A brine (salt) solution is passed through the unit to regenerate the resin. This usually takes 45 – 60 minutes to "recharge" the resin with sodium ions.

Stage Three

Remaining waste products and excess brine are rinsed from the softener. The unit is basically placed in service except that the softener effluent (wastewater) goes to waste instead of to the distribution system. This generally lasts between 20 – 40 minutes.

Upon completion of the backwash cycle, all the calcium and magnesium ions should have been removed from the resin and replaced with sodium ions. It should be noted that the method of disposing of the softener backwash water is often a major consideration. Waste discharge must be disposed of properly to prevent environmental contamination and erosion. Softener backwash should not go into an onsite septic system as it may have a negative impact on the septic tank biological activity needed for treatment of waste.

The backwash drain line shall not terminate into a floor drain or sewer line. An air gap is required by law to separate the drinking water supply from the wastewater system to protect public health.

11.3 Cartridge Filtration

Cartridge filters are often used by small facilities to remove organic chemicals that can cause offensive tastes and odors. These devices may be installed to treat an entire system or a single point of use (POU). As the system must be opened to exchange filters, care must be taken to routinely maintain all filtration devices to prevent bacterial growth.

11.4 Limited Treatment Permitted Systems

Public health related treatment of groundwater sources such as removal of nitrate or arsenic to meet a drinking water standard is required to be permitted and approved prior to installation and must have at least a D level certified operator. If the treatment is not properly operated, the system could exceed a drinking water standard which has public health implications.

Other treatment which has potential to impact public health must be permitted and managed by a D level certified operator. These treatment systems typically inject a chemical into the drinking water such as chlorine, phosphate, or potassium permanganate. Even though the treatment installation is for aesthetic reasons, overfeed of a chemical or feeding the wrong chemical is a public health concern.

11.5 Disinfection

Some examples of disinfection agents include chlorine, iodine, bromine, ozone, ultraviolet rays, and heat. Chlorine bleach is typically used in small water supplies for new well construction or if disinfection of the existing well and distribution system is necessary. Liquid bleach with additives or solid compounds with stabilizers or binders should not be used in drinking water systems.

The chemical should also be safe and easy to handle, and it should not make the water toxic or unpalatable. The concentration of disinfectant in the water must meet prescribed limits, be easy to monitor and the disinfection must provide residual protection against possible recontamination.

If well construction/location cannot provide a safe water source (i.e., groundwater under the influence of surface water) and continual treatment is required, biological contaminants are most effectively eliminated by disinfecting water through oxidation (e.g., chlorine disinfection or ozonation), and filtration. For each method, the equipment must be specifically designed for the intended use and properly maintained to allow for effective filtration and contact time for treatment. Ultraviolet and ozonation are not permitted as stand-alone disinfection methods to meet water quality standards. A chemical disinfectant residual must also be maintained in the distribution system. However, regular bacterial analysis of the treated water is also needed to ensure adequate treatment occurs.

Chemical feed equipment must be automatic, require minimal maintenance, and treat all water in the distribution system. It should also be fail-safe so no one will unknowingly use or consume contaminated water.

11.5.1 Chlorine

Chlorination is the most common method of disinfection. It also helps control microorganisms that could produce slimes, tastes, or odors in the distribution system water.

Chlorine is used as an oxidant in arsenic removal and as a post treatment disinfectant in the coagulation-flocculation, sedimentation, and filtration treatment process.

There are different forms of chlorine that may be used. Hypochlorite is available in solid (tablet) or liquid (pump-fed solution) forms. Use of gaseous chlorine places greater demand on the need for isolated plant space, on providing trained and attentive operating staff and their protection from any hazards, and, possibly, on liability issues which may boost insurance costs for small public water systems.

When chlorine is used as a disinfectant, chlorine residual must be maintained throughout the distribution system. Always be sure to measure the chlorine residual in the distribution system daily, especially at the farthest end of the system, and properly document the results.

It is important to make sure the chlorine equipment is working properly; the pump, the inlet to distribution pipe is not clogged up, the strainer in the bottom of the solution container is not plugged, and there is enough chlorine solution in the container.

Chlorine can be hazardous to your health. Always take precautionary measures when handling chlorine. Wear protective clothing and breathing apparatus if necessary and wash your hands. If there is a spill, clean up immediately by using large amounts of water and if any is spilled on you, quickly wash all affected areas with water. Hypochlorite solutions are also very corrosive. There are specific regulations regarding the use of chlorine and chlorine disinfectant by-products mandated by federal law.

Factors Influencing the Disinfection Properties of Chlorine:

- pH – chlorine disinfects better at a lower pH than a higher pH
- Temperature – disinfection is more efficient the higher the temperature of the water
- Turbidity – disinfection is less effective with suspended particles (turbidity) present
- Reducing Agents – these materials react with chlorine and will use it up before any disinfection can occur
- Number and Types of Microorganisms – the higher instance of microorganisms, the greater the demand for chlorine
- Contact Time – the longer the time chlorine is in the water the better the disinfection

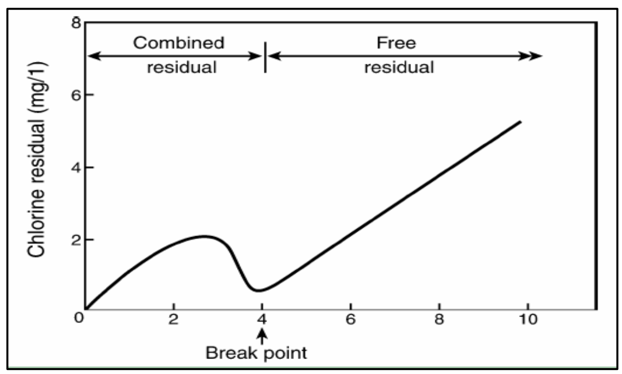
Common Terms

- Free Available Chlorine: The concentration of hypochlorous acid and hypochlorite ions in the water.
- Total Chlorine Residual: The amount of chlorine remaining in the free and combined form after a certain contact time.
- Free Chlorine Residual: The amount of chlorine that has not reacted with other compounds found in the water.
- Combined Chlorine Residual: Is the amount of chlorine that has reacted with natural ammonia or organic nitrogen compounds in the water to form chloramines.
- Chlorine Demand: The difference between the chlorine applied and chlorine residual. Usually, the amount of chlorine that has reacted with or is lost to other substances in the water and is not found as a free or combined chlorine residual.

Breakpoint Chlorination

Breakpoint chlorination is the process of adding chlorine to water until the chlorine demand has been satisfied and further addition of chlorine results in a chlorine residual that is "free" to kill or inactivate microorganisms. The highest disinfection ability of chlorine is when it is in the form of "free available residual."

Figure 11-1



Water naturally contains organic and inorganic materials which chlorine combines with to form chlorine compounds some of which do not have disinfecting properties. If you continue to add chlorine, you eventually reach a point where the reaction with organic and inorganic materials stops. At this point, you have satisfied what is known as the "chlorine demand."

Some chlorine reacts with water and produces some substances with disinfecting properties. The total of all the compounds with disinfecting properties plus any remaining free (uncombined) chlorine is known as the "chlorine residual." The chlorine residual can be measured with an approved test kit and indicates that all chemical reactions with chlorine have been completed and there is still enough "free available residual chlorine" to kill or inactivate any microorganisms present in the water supply. Currently, the diethyl-p-phenylenediamine (DPD) titrimetric and colorimetric methods are the two most common field tests for determining chlorine residuals. In the DPD colorimetric method, the chlorine residual can be determined by comparing the color development with known-colored standards. A pinkish color will develop in the presence of chlorine. "Chlorine dose" is the amount of chlorine that must be added to the water to disinfect it.

Positive Displacement Chemical Feeders

A common type of positive displacement hypo-chlorinator is one that uses a piston or diaphragm pump to inject the solution. This type of equipment, which is adjustable during operation, can be designed to give reliable and accurate feed rates. The stopping and starting of the hypo-chlorinator can be synchronized with the well pumping unit by plugging it into an outlet that is energized when the well pump is on.

A hypo-chlorinator of this kind can be used with any water system. However, it is especially desirable in systems where water pressure is low and fluctuating.

Chlorine Residual Testing

When continuous chlorination is used for disinfection, a residual of 0.2 to 0.5 ppm free chlorine should be maintained at all points in the distribution system. This will help ensure that effective disinfection is occurring at all points on the distribution system. In some cases, residuals will be higher than the 0.2 to 0.5 ppm range due to treatment specifications (such as surface water treatment). However, concentrations must not be higher than 4 ppm in the distribution system. Chlorine residual can be measured using a field test kit that uses the DPD analysis method. There are many chemical companies that manufacture chlorine residual testing equipment.

Figure 11-2

Operators of a chlorinated water supply are required to maintain a Monthly Operation Report (MOR) on a form provided by EGLE. Records are kept for chlorine residual daily with results entered immediately after each test. A copy of the MOR shall be submitted to the LHD. Example MORs can be found on the EGLE website: Michigan.gov/EGLE/0,9429,7-135-3313_3675_3692-107363--,00.html.

Figure 11-3

EGLE

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
DRINKING WATER AND ENVIRONMENTAL HEALTH DIVISION
ENVIRONMENTAL HEALTH SECTION

MONTHLY OPERATION REPORT – CHLORINE INJECTION

Facility Name________________________ WSSN________________

Certified Operator________________ #________ Month/Year: ______/______

Day	Flow Meter Reading (Gallons)	Free Chlorine Residual (mg/L)	Visual Inspection (Y/N)	Comments	Inspected By
1					
2					
3					
4					
5					
6					
7					

It is required that chlorine residual tests be performed and recorded at least once daily at a sample point on the distribution system that is representative of the water being used for drinking purposes.

11.6 Lead and Copper Corrosion Control

Corrosive water can cause serious problems to the water system and health of individuals. Corrosion is a gradual destruction of materials, such as metal pipes, due to a chemical action from the water. The water becomes corrosive because of stray electrical currents or metals in the water that react with the metal of the pipe. Corrosion starts at the surface of a material and moves inward. It can occur on the interior or exterior of metal piping and equipment.

Factors that influence corrosion include physical factors, such as the type of water system materials, stray electrical currents, an increase in water temperature, low flow velocity of water in the pipes (stagnant water areas); chemical factors, such as alkalinity, pH, dissolved oxygen, hardness, chlorides, and metals in the water; and certain bacterial growth in the system.

The Lead and Copper Rule requires water systems to monitor and control corrosion to protect the public from harmful effects of lead, copper, or other toxic metals in drinking water. There are various methods that may be utilized to minimize system corrosion. Some examples include changing the water's characteristics, such as adjusting pH and alkalinity; softening the water with lime; and changing the level of dissolved oxygen. Chemical control depends on the original water quality characteristics. Ion Exchange, Reverse Osmosis, Lime Softening, and Coagulation/ Filtration are possible source water treatment methods (SDWA Rule 604f). Some measures (e.g., adding phosphates or silicates) are used to provide a protective coating on the piping, which helps stop or reduce the leaching of lead and copper from pipes.

Replacement or removal of lead and copper service lines, pipes, fixtures, and lead solder is also a method used to reduce the leaching effect of lead and copper from corrosive water.

11.7 Phosphate Treatment (iron sequestration treatment)

Phosphate and polyphosphate are general terms used to denote several types of phosphate compounds used in water treatment. In the water treatment industry, phosphate is mainly used for controlling iron problems, for the stabilization of lime-soda softened water, and for boiler feed water stocks. Phosphate is only effective in certain types of water and under certain conditions. Phosphate combines with or sequesters dissolved iron and keeps it in solution. It does not remove iron from solution, like ion exchange or aeration, nor does it combine with precipitated ferric iron. This sequestering action of phosphate with iron will be less effective with an increase in time or temperature.

Phosphate can be applied to water by a positive displacement chemical feed pump which operates when the well pump is turned on. Disinfection is required following treatment with phosphate because phosphate can act as a nutrient for bacteria. Phosphate should be applied ahead of aeration or chlorination since it must be introduced before oxidation of the iron occurs. Only nontoxic solutions (ANSI/NSF approved products only) may be used and at the proper dosage. The dosage for water systems should always be kept below 10 ppm.

11.8 Iron and Manganese

Iron and manganese may promote the growth of bacterial slimes in the distribution system. These slimes are rust colored from iron and black from manganese. Foul tastes and odors are often associated with these slimes, and dirty water may occur if the slimes break loose.

Iron and manganese may be treated in the same manner. The method most used involves three steps: oxidation, detention, and filtration. However, other methods such as greensand filtration and ion exchange may also be used. Arsenic may also be removed with the iron in these processes.

11.8.1 Greensand Filtration

Iron and manganese can also be effectively removed by filtering the water through manganese-treated greensand which is a mineral capable of exchanging electrons and thereby oxidizing iron and manganese's to their insoluble, filterable states. Again, greensand filtration may also be effective for arsenic removal.

One major advantage of this type of treatment method over the aeration, detention, filtration method is that double pumping is eliminated.

11.8.2 Ion Exchange

Small amounts of soluble iron and manganese may be removed using ion exchange. In this case, sodium ions are exchanged for iron and manganese ions, however, this process is extremely expensive, and the resins can easily become fouled with iron and manganese. Therefore, ion exchange is typically not utilized as an iron or manganese removal technique.

11.9 Nitrate Anion Exchange

Nitrates can be removed using an anion exchange treatment unit that may look like a water softener on the exterior; however, it uses a resin different than that of a water softener. The resin inside the anion system is selected to target nitrates in the water.

There are several types of anion exchange resins, each designed to remove specific contaminant(s). Another example would be an anion exchange system using a strong base “sulfate-selective” to reduce arsenic.

11.10 Activated Carbon

Carbon material in this type of treatment reduces organic chemicals, such as those that can cause offensive tastes and odors by adsorption. Adsorption is the attraction and accumulation of one substance on the surface of another. It is primarily a surface phenomenon; the larger the surface area of the adsorber, the greater its adsorptive power. Activated carbon filters may be installed either to treat an entire system or just a single point of use (POU).

Bacterial growth in the media or the shedding of bacteria to the distribution system is a problem in carbon filters if they are not properly operated and maintained. Activated carbon filters have limited capacity, so frequent replacement of the filter media or cartridge is necessary, or bacteria will slough off into the drinking water supply.

11.11 Adsorption Medias for Arsenic (As) Removal

Adsorption is contaminant removal from water by attachment onto the surface of a porous solid. These types of medias will be a popular choice for arsenic removal due to the ease of operation and their ability to remove both As (III) and As (V). However, these systems are much more efficient if the arsenic is in the (V) form. There are two common types of adsorption medias, iron based, and aluminum based.

11.12 Reverse Osmosis (RO)

RO is a membrane process that can effectively remove nearly all inorganic contaminants such as nitrates and arsenic from water. In the RO unit, water passes through a synthetic, semi-permeable membrane that filters all pathogens and most organic and inorganic contaminants. This system uses pressure to force the water through the tiny pores in the membrane, trapping the contaminant on the membrane.

These units must have a means of discharging filtered matter to a drain. The discharge line must be installed with an air gap so a cross connection between wastewater and drinking water will not occur.

Proper maintenance is critical to the use of a RO device as the membrane will become plugged with contaminants. RO units are often installed to treat a single point of use fixture.

11.13 Ozone

Ozone is a powerful oxidant with high disinfectant capacity. The pH and temperature of the water influences the microorganism inactivation capabilities of ozone. Ozone disinfection of the drinking water is not widely used in NCWS.

Chapter 12

Complete Treatment

Act 399, Part 1, Rule 103 provides the definition of complete treatment. "Complete treatment means a series of processes, including disinfection and filtration, to treat surface water or ground water under the direct influence of surface water, or to treat ground water not under the direct influence of surface water that uses precipitative softening, to produce a finished water meeting state drinking water standards."

A NCWS with treatment meeting the definition of a complete treatment system is required to have a Level F-5 certified operator:

12.1 Surface Water Treatment Rule (SWTR)

The SWTR affects all PWS's that use surface water or groundwater under direct influence of surface water and are defined as "Subpart H" systems in the SDWA. The purpose of this rule is to improve public health protection through the control of microbial contaminants, particularly viruses, Giardia, and Cryptosporidium. This rule establishes criteria under which filtration is required. Subpart H systems must provide filtration and disinfection or find an alternative safe ground water source.

12.2 Disinfection Requirements for Subpart H Systems

Small drinking water systems using complete treatment processes typically will use liquid chlorine as a disinfectant.

Subpart H systems shall provide enough disinfectant contact time (CT) before the water enters the distribution system to assure adequate disinfection. CT refers to the product of the residual disinfectant concentration in mg/L, "C," and the disinfectant contact time in minutes, "T." The disinfectant contact time is defined as the time required for the water being treated to flow from the point of disinfectant application to a point before or at the first customer during peak hourly flow. There is a relationship between CT and percent inactivation (log inactivation) for a given disinfectant. Since the determination of percent removal of a microbiological contaminant is more technically demanding than the calculation of CT, CT is used as a surrogate for percent removal for a given disinfectant.

12.3 Turbidity Monitoring Requirements

Turbidimeters (also referred to as "turbidity meters") detect the intensity of light scattered at one or more angles to an incident beam of light. Turbidimeters are in widespread use throughout the water industry and the turbidity data generated by these instruments is broadly recognized as a meaningful gauge of water quality.

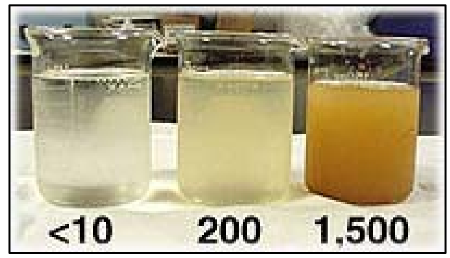
The SWTR specifies turbidity monitoring as the default method for continuous indirect integrity monitoring of filtration membranes unless the state approves an alternate approach. There are two ways turbidity is measured: Combined Filter Effluent (CFE) and Individual Filter Effluent (IFE).

CFE monitoring frequency is at least every four (4) hours (unless reduced by the state on an individual basis). Using IFE, filtrate turbidity must be monitored on each discrete membrane unit at a minimum frequency of once every 15 minutes.

Turbidity is measured in Nephelometric Turbidity Units (NTU). The maximum levels of turbidity are as follows:

CFE 95% Value:	≤ 0.3 NTU
CFE Maximum Value:	1 NTU
IFE Monitoring:	0.15 NTU

Image 12-1



Two consecutive readings exceeding a control limit of 0.15 NTU for any one unit would require that unit to undergo direct integrity testing and subsequent diagnostic testing, as necessary. Any such events that trigger direct integrity testing must be reported to the state monthly.

12.4 Coagulation and Flocculation

These processes are used to remove particulate impurities such as solids that do not settle out of water (causing turbidity) and color from water which typically are found in surface water sources. Groundwater sources that are not under the influence of surface water do not use this type of treatment. Turbidity reduction is best achieved when the water is run through a series of chemical and physical treatment methods before reaching a filter. Coagulation is the process of getting particulates to stick together and flocculation is usually a two or three stage process of slow mixing which gets the particulates to become more visible. Flocculation allows the particles to get heavier which helps them settle to the bottom in the sedimentation part of the process.

12.5 The Sedimentation Process

Sedimentation is also a process utilized by surface water and groundwater sources under the influence of surface water to remove suspended solids. During this stage, the particles of dirt settle to the bottom of the basin (becoming sludge) and the water is free to continue flowing to the filters for further "polishing." The sludge is periodically removed.

12.6 Filtration

The process of filtration is to remove suspended solids from water by passing the water through a "bed" of sand, coal, or other granular substance or through a permeable fabric. The unwanted particles are trapped but the water passes through. Filtration is both a physical and chemical process. Some examples of filtration include Gravity Filtration, Pressure Filtration, Diatomaceous Earth Filtration, and Sand Filtration. If a filter media is used, it is selected based on what substance needs to be filtered out. Filtration is used along with the coagulation and flocculation and sedimentation processes and is the last stage in turbidity control. Filtration is the most used treatment for reducing turbidity and microbial contaminant levels in domestic water supplies. Common drinking water filtration processes involve passing water through a filter media to remove suspended particulate material, larger colloidal materials, and, for some filter media, to reduce levels of smaller colloidal and dissolved contaminants.

Examples of suspended particulates include clay and silt, microorganisms, organic materials, and aluminum and iron oxide precipitates. Familiar filter media include silica sand, diatomaceous earth, garnet or ilmenite, and a combination of coarse anthracite coal overlaying finer sand. Filtration may be rapid or slow, depending upon the application, and may involve different removal processes, cleaning methods, and operation methods.

12.6.1 Conventional Filtration

Conventional filtration includes pre-treatment steps of chemical coagulation, rapid mixing, and flocculation, followed by floc removal via sedimentation or flotation. After clarification, the water is then filtered. Common filter media include sand, dual-media, and tri-media. Design criteria for specific sites are influenced by site- specific conditions and thus individual components of the treatment may vary in design criteria between systems. Conventional treatment has demonstrated removal efficiencies greater than 99% for viruses and 97 to 99.9% (rapid filtration with coagulation and sedimentation) for Giardia lamblia.

Conventional filtration is the most widely used technology for treating surface water supplies for turbidity and microbial contaminants but may be less applicable to the smallest water system size category (those serving 25 to 500 persons) due to relatively high costs and technical complexity. Although conventional filtration has the advantage that it can treat a wide range of water qualities, it has the disadvantage that it requires advanced operator skill and has high monitoring requirements. Thus, small systems without access to a skilled operator should not use conventional treatment, given that waterborne pathogens are acute contaminants, and that the disruption of chemical pre-treatment can lead to pathogen introduction into the distribution system.

12.6.2 Direct Filtration

Direct filtration has several effective variations, but all include a pre-treatment of chemical coagulation followed by rapid mixing. The water is then filtered through dual- or mixed-media using pressure or gravity filtration units. Pressure units, which are used primarily by small systems, have the advantage of not requiring re- pumping for delivery of the filtrate to the point of use. Gravity units have the advantage of allowing easy visual inspection of the filter medium during and after backwash. Direct filtration has the disadvantage that it requires advanced operator skill and has high monitoring requirements. Thus, small systems without access to a skilled operator should not use direct filtration, given that waterborne pathogens are acute contaminants, and that the disruption of chemical pre-treatment can lead to pathogen introduction into the distribution system.

12.6.3 Slow Sand Filtration

Slow sand filters are simple, are easily used by small systems, and have been adapted to package plant construction.

12.6.4 Diatomaceous Earth (DE) Filtration

DE filtration, also known as pre-coat or diatomite filtration can be used to directly treat low turbidity raw water supplies. DE filters consist of a layer of DE supported on a septum or filter element. Problems inherent in maintaining the filter cake have limited the use of DE filtration and this technology is typically not used in small systems.

12.6.5 Membrane Filtration

Membrane filtration involves a thin layer of semi-permeable material capable of separating substances when a driving force is applied across the material. Membranes are manufactured in a variety of configurations, materials, and pore size distributions. The selection of membrane treatment for a drinking water application would be determined by several factors, such as: targeted material(s) to be removed; source water quality characteristics; treated water quality requirements; membrane pore size; molecular weight cutoff (MWC); membrane materials and system/treatment configuration.

The membrane filtration process is increasingly employed for removal of bacteria and other microorganisms, particulate material, and natural organic materials. Pressure-driven membrane processes are microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO).

12.6.6 Microfiltration (MF)

MF is commonly used to remove Giardia lamblia and Cryptosporidium cysts in drinking water obtained from surface water. It is not an absolute barrier to viruses; however, when used in combination with disinfection MF appears to control these microorganisms.

MF and UF utilize low operating pressures for the removal of particulates including pathogenic cysts. Due to typical MF membrane pore sizes and size exclusion (e.g., 0.1 to 0.2 micron, macro- molecular/micro-particle range); MF is effective for absolute removal of Giardia cysts and partial removal of bacteria and viruses, and when used in combination with disinfection, appears adequate for removal/inactivation of these microorganisms.

Tests have been determined that MF filtrate turbidity may be kept below 0.2 NTU and typically at or below 0.1 NTU.

Pre-filtration and scale-inhibiting chemical addition may be utilized to protect membranes from plugging effects, fouling and/or scaling, and to reduce operational and maintenance costs. For the purposes of meeting the performance criteria under the SWTR and as a safety measure, a disinfectant is commonly applied following membrane treatment to protect distributed water quality.

12.6.7 Ultrafiltration (UF)

UF, characterized by a wide band of "molecular-weight cutoffs" (MWCO) and pore sizes, is used for removal of specific dissolved organics (e.g., humic substances, for control of disinfection by-products in finished water) and for removing particulates. Due to typical UF membrane pore sizes and size exclusion capability (e.g., 0.01 micron, molecular/macromolecular range), UF is effective for absolute removal of Giardia cysts and partial removal of bacteria and viruses, and when used in combination with disinfection appears adequate for removal/inactivation of these microorganisms. Tests have also shown that filtrate turbidity may be kept consistently at or below 0.1 NTU).

12.6.8 Nanofiltration (NF)

NF and RO constitute the class of membrane processes that is most often used in applications that require the removal of dissolved contaminants. While NF and RO are sometimes referred to as "filters" of dissolved solids, NF and RO utilize semi-permeable membranes that do not have definable pores. NF and RO processes achieve removal through the process of reverse osmosis, as described below. However, these membrane processes also represent a barrier to particulate matter. Osmosis is the natural flow of a solvent, such as water, through a semi permeable membrane (acting as a barrier to dissolved solids) from a less concentrated solution to a more concentrated solution. This flow will continue until the chemical potentials (or concentrations, for practical purposes) on both sides of the membrane are equal. The amount of pressure that must be applied to the more concentrated solution to stop this flow of water is called the osmotic pressure. An approximate rule of thumb for the osmotic pressure of fresh or brackish water is approximately 1 psi for every 100 mg/L difference in total dissolved solids (TDS) concentration on opposite sides of the membrane.

RO is the reversal of the natural osmotic process, accomplished by applying pressure more than the osmotic pressure to the more concentrated solution. This pressure forces the water through the membrane against the natural osmotic gradient, thereby increasingly concentrating the water on one side (i.e., the feed) of the membrane and increasing the volume of water with a lower concentration of dissolved solids on the opposite side (i.e., the filtrate or permeate). The required operating pressure varies depending on the TDS of the feed water (i.e., osmotic potential), as well as on membrane properties and temperature.

Because semi-permeable NF and RO membranes are not porous, they can screen microorganisms and particulate matter in the feed water; however, they are not necessarily absolute barriers. NF and RO membranes are specifically designed for the removal of TDS and not particulate matter. Nonetheless, NF and RO are eligible for Cryptosporidium removal credit based on the demonstrated ability of these technologies to remove pathogens, as well as on the high probability that these processes can meet the requirements for membrane filtration specified in the rule.

The ability to maintain system integrity is one of the most important operational concerns associated with any membrane filtration facility. Because a membrane represents a physical barrier to pathogens and other drinking water contaminants, the means to ensure that this barrier remains uncompromised is critical for the ongoing protection of public health.

Due to typical NF membrane pore sizes and size exclusion capability (1 nanometer range, e.g., organic compounds); NF is effective for removal of cysts, bacteria, and viruses.

12.7 Membrane Information

In general, MF and UF use hollow-fiber membranes, and NF and RO use spiral- wound membranes. The terms hollow-fiber, spiral- wound, and cartridge refer to the module in which the membrane media is manufactured. Normally, the membrane material is manufactured from a synthetic polymer, although other forms, including ceramic and metallic membranes, may be available.

The material properties of the membrane may significantly impact the design and operation of the filtration system. For example, membranes constructed of polymers that react with oxidants commonly used in drinking water treatment should not be used with chlorinated feed water. Mechanical strength is another consideration, since a membrane with greater strength can withstand larger transmembrane pressure (TMP) allowing for greater operational flexibility and the use of higher pressures with pressure-based direct integrity testing.

Similarly, a membrane with bi-directional strength may allow cleaning operations or integrity testing to be performed from either the feed or the filtrate side of the membrane. Material properties influence the exclusion characteristic of a membrane as well. A membrane with a particular surface charge may achieve enhanced removal of particulate or microbial contaminant of the opposite surface charge due to electrostatic attraction. In addition, a membrane can be characterized as being hydrophilic (i.e., water attracting) or hydrophobic (i.e., water repelling). These terms describe the ease with which membranes can be wetted, as well as the propensity of the material to resist fouling to some degree.

Membrane filtration media is usually manufactured as flat sheet stock or as hollow fibers and then configured into one of several different types of membrane modules.

There are a few general concepts that are applicable to all types of pressure-driven membrane filtration systems, and which serve as the underlying basic principles for system design and operation. These concepts include flux, recovery, and flow balance (see the U.S. EPA Membrane Filtration Guidance Manual, page 70 for equations and calculation).

12.7.1 Membrane Integrity Testing

For a membrane process to be an effective barrier against pathogens and other particulate matter, the filtration system must be integral, free of any leaks or defects resulting in an integrity breach. Thus, it is critical that operators can demonstrate the integrity of this barrier on an ongoing basis during system operation. Indirect integrity testing methods include turbidity monitoring and particle counting and monitoring. Direct integrity testing methods include air pressure tests; bubble point testing; and sonic wave sensing.

Direct Integrity Testing
A direct integrity test is a physical test applied to a membrane unit to identify and isolate integrity breaches. Direct integrity testing represents the most accurate means of assessing the integrity of a membrane filtration system that is currently available. To receive Cryptosporidium removal credit for compliance with the SWTR, the removal efficiency of a membrane filtration process must be routinely verified during operation using direct integrity testing. The direct integrity test must be applied to the physical elements of the entire membrane unit, including membranes, seals, potting material, associated valves and piping, and all other components which could result in contamination of the filtrate under compromised conditions.

Although there are several types of direct integrity tests, the most common method is the pressure decay test, which measures the rate of pressure loss across the membrane relative to a maximum acceptable threshold.

Indirect Integrity Testing

Indirect integrity monitoring methods are not physical tests applied specifically to a membrane module or membrane unit, but instead involve monitoring some aspect of filtrate water quality as a surrogate measure of membrane integrity. Because the quality of membrane filtrate is very consistent and independent of fluctuations in feed water turbidity or particle levels, a marked decline in filtrate quality may indicate an integrity problem. Although indirect integrity monitoring is not as sensitive as direct testing for detecting integrity breaches, the indirect methods offer some significant benefits that make them an important and useful tool in an overall integrity verification strategy. These benefits include both the ability to be operated in a continuous, on-line mode and the non-proprietary nature of the indirect techniques, such that the same indirect method is similarly applicable to any membrane filtration system independent of manufacturer, configuration, or other system parameters.

While direct integrity tests can be extremely sensitive and thus can potentially verify high log removal values, most direct test methods require that the membranes be taken off-line (i.e., out of production mode) to undergo testing. Thus, these direct tests are limited to periodic application to minimize system down time. A failed periodic direct integrity test indicates that an integrity breach occurred at some time between the most recent direct test in which integrity has been verified and the failed test but indicates nothing about integrity over the period between direct test applications. Continuous monitoring using indirect methods does provide a real-time indication of membrane integrity, albeit with less sensitivity in most cases. Consequently, the advantages of the direct and indirect integrity monitoring approaches are complementary, and both are critical elements of a comprehensive integrity verification program (IVP).

Membrane Failures

There are several potential modes of failure associated with membrane filtration systems that would result in an integrity breach. For example, membranes may become damaged via exposure to oxidants (chlorine), pH levels outside the recommended range, or other chemicals or operating conditions to which the membranes are sensitive. In addition, membranes may break or puncture because of extreme pressure, scratches or abrasions, or operational fatigue over time. Spiral- wound membranes can be damaged at glue lines if the pressure on the filtrate side of the membrane exceeds that on the feed side.

Factory imperfections such as glue line gaps or potting defects may cause integrity breaches, as well. Improper installation of membrane modules can also create integrity problems at O-rings or interconnections.

Membrane Filter Maintenance

One of the most critical aspects of employing membrane technology is ensuring that the membranes are intact and continuing to provide a barrier between the source water and the drinking water.

Filtration devices will eventually “clog up” and exhibit high head loss (pressure drop) after a given time depending on the number of suspended solids in the water. When a filter becomes overloaded and can no longer take up the impurities that are targeted for removal, these materials will “breakthrough” the filter and be released into the distribution system. In the case of filtration for substances that may cause adverse health effects, this breakthrough could be dangerous. Therefore, it is important for the operator to properly operate, monitor and maintain this treatment device. In general, membranes can be fouled by an accumulation of inorganic and organic compounds. Bacteria can also adhere to the membranes and create biofilms.

A change in operating conditions, periodic backwashing, and chemical cleaning are methods that may be used to control or get rid of fouling on the membrane. Several chemical cleaning techniques can be employed including chlorinated cleaning, however only certain membranes can withstand this method. An operator should always refer to manufacturer’s recommendations on the maintenance of equipment. Because other chemicals such as acids or caustics may also be used in the cleaning process, safety issues are also involved.

Water that goes out of the filter into the distribution system should be monitored closely for turbidity. Backwashing is the process of reversing the flow of water through the filter media to remove the entrapped solids. Backwashing should occur when a filter reaches its maximum head loss, when a specific time has occurred (based on manufacturers recommendation), or if breakthrough occurs. During this process filtration is stopped.

Chapter 13

Basic Mathematics

The drinking water operator must be familiar with phrases such as gallons per day, cubic feet per second, pounds of chlorine, gallons per minute, and pounds per square inch. Much of the work involved with these phrases requires arithmetic and some algebraic calculation. The basic operations of arithmetic are addition, subtraction, multiplication, and division. This section only highlights some basic mathematical information and calculations.

13.1 Algebra

Algebraic calculations basically deal with signs and symbols used to solve problems (or for solving the "unknown"). Frequently, the letter "X" is used to represent the unknown and parentheses ( ) are used to denote the multiplication function.

To solve for the unknown X, two basic objectives are considered:

1. Get X to the numerator
2. Clear all other numbers from the X side of the equation to get X alone

13.2 Units of Measurement

There are two systems of measurement: the English system, and the metric system. Numbers can be assigned a unit of measurement to depict length, width, area, volume, etc. When conducting mathematical calculations of quantities, the quantities must be in the same units. If they are not, convert all units to a common unit.

Common units or terms used in waterworks operations:

gpm	= gallons per minute	lb.	= pound
gpd	= gallons per day	ppm	= parts per million
mgd	= million gallons per day	ppb	= parts per billion
cfs	= cubic feet per second	mg/L	= milligrams per liter
psi	= pounds per square inch		(mg/L is same as ppm)

Common conversions from one unit to another:

Multiply	By	To Obtain
cubic feet (ft^3 or cu. ft.)	62.4	pounds (lbs.) of water
gallons of water	8.34	pounds (lbs.) of water
feet of water (ft)	0.433	pounds per square inch (psi)

Velocity (speed) of flow of water is often expressed as feet per minute (fpm) or feet per second (fps). The rate of flow (Q) indicates how much water is moving past a spot in a unit of time and is expressed as gallons per unit of time. Pump capacities are usually expressed in gallons per minute (gpm).

13.3 Solving Equations

Most of the arithmetic problems the operator will work with requires plugging numbers into formulas and calculating the answer. There are a few basic rules that apply to solving formulas:

- Work from left to right.
- Do all multiplication and division above the line (in the numerator) and below the line (denominator); then do the addition and subtraction above and below the line.
- Perform the division (divide the numerator by the denominator).
- Complete all arithmetic within parentheses before working outside the parentheses.

13.4 Decimals

The decimal system is a way of counting or measuring using units that are powers of ten such as thousands, hundreds, tens, ones, tenths, hundredths, or thousandths. Whole numbers are written to the left of the decimal point. Fractions are written to the right of the decimal point.

Rules for rounding decimals:

- Look to the right of the place to which you want to round.
- If the digit to the right of that place is 5 or greater than 5, round up.
- If the digit to the right is 4 or less than 4, do not change the number in the place you are rounding to.

13.5 Fractions

A fraction is an unexecuted division and involves a numerator and denominator separated by a "fraction bar." A fraction can be converted into a decimal by dividing the numerator by the denominator:

$$\frac{\text{numerator}}{\text{denominator}}$$

Examples: 1/4 = 1 ÷ 4 = 0.25
2/3 = 2 ÷ 3 = 0.67

13.6 Percentage

Percent means parts per 100 parts. "Per" means divided by and a percent is the numerator of a fraction whose denominator is always 100. Percentage computations are frequently made by operators when calculating chlorine dosages and other chemical feed rates, pump, and motor efficiencies and in other instances.

Examples: $\frac{50}{100} = 50\%$ $\frac{2.5}{100} = 2.5\%$

13.7 Computing Chlorine Injection

Injection of chlorine is calculated by parts per million (ppm) which equates to pounds of chlorine for every million pounds of water. Chlorinator adjustment is usually by pounds per day of chlorine and is calculated based on how many million pounds of water are being treated in 24 hours and adjusting 1 pound of chlorine for each million pounds of water.

When calculating the concentration of a chemical in water, the weight of the chemical is placed on the top part of the concentration formula and the weight of water (expressed in millions of units), is put on the bottom of the formula.

ppm = pounds of pure chemical per million pounds of water
mg/L = milligrams of chemical per million liters of water

The disinfection example problems on the following pages are from the Limited Treatment Course "Water Distribution and Limited Chemical Treatment Review Manual" (2nd edition). This course is recommended for certified drinking water operators involved with water treatment.

Chapter 14

Cross Connection Control

A cross connection is a direct connection of a potable water source with any system, equipment or fixture which contains nonpotable water. Cross connections can affect water quality and create health problems due to contamination from backflow.

Cases of illness, disease, and death have been documented as resulting from cross connections between potable water systems and non-potable water, sewage, and chemicals. Increased awareness and vigilance through cross connection prevention programs have reduced the number and severity, but “incidents” continue to occur.

14.1 Backflow

Backflow is an undesirable reversed flow in a piping system. Backflow can be caused by backsiphonage, backpressure, or a combination of the two.

Backsiphonage Backflow
Backsiphonage backflow occurs when there is a partial vacuum (negative pressure) in a potable water supply system, potentially drawing contaminants into the water supply. The effect is like sipping a soda by inhaling through a straw.

Heavy water demands, such as those created by firefighting, repairs or breaks in municipal mains, and others, may create this back-siphonage situation. Under these conditions, hoses dangling in chemistry, biology, or photography laboratory sinks, janitors slop sinks, or other systems can provide the connection through which backflow (by back-siphonage) can occur.

Backpressure Backflow
Backpressure backflow occurs when the pressure of the non-potable system exceeds the positive pressure in the potable water distribution lines.

These situations may develop when a potable water supply system is directly or indirectly connected to heating systems, elevated tanks, pressure-producing systems, individual water supply systems, and the like. For example, if a boiler used in conjunction with a heating system is operating at 15 psi pressure and the potable water supply system is operating at 20 psi, and something happens to reduce the pressure in the potable water supply system, the water pressure from the boiler will exceed the system pressure. Since water flows from high pressure to low pressure, the backpressure situation would allow boiler water to flow into the potable system.

Prevention of cross connection contamination of the drinking water supply is the best management practice an operator can have. A water system should develop a sound program that eliminates health hazards caused by cross connections. Elimination of all direct connections between potable and nonpotable water is the best means of preventing cross connections.

14.2 Backflow Prevention Techniques

If a cross connection is discovered, its elimination first involves determining how backflow might occur in that situation. If backflow can only occur by backsiphonage, then a specific backflow prevention device may be required. If, however, backflow could occur by either backsiphonage or backpressure, then that same device may not be appropriate.

Refer to the Michigan Plumbing Code and the EGLE Cross Connection Control Manual (Michigan.gov/Documents/DEQ/CrossConnectionManual_251521_7.pdf) for specifics and appropriate use of devices. All approved backflow prevention devices must meet the Michigan Plumbing Code regulations and NSF/ASSE standards.

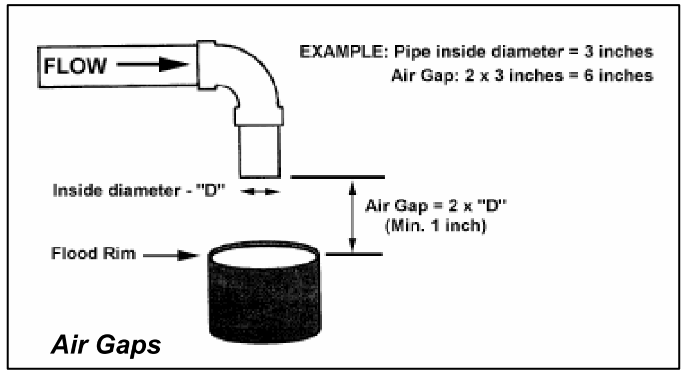
There are several basic ways to prevent or reduce the possibility of backflow in cross connections: air gaps; atmospheric vacuum breakers; hose bib vacuum breakers; pressure type vacuum breaker assemblies; double check valve assemblies; dual-check valve with intermediate atmospheric vent; and reduced- pressure backflow prevention assemblies. The most reliable means of preventing backflow is an air gap.

14.2.1 Air Gap

An air gap is a physical separation of the potable and nonpotable systems by an air space. It cannot be used however for a direct connection to a pressurized system. An approved air gap must be at least two (2) times the diameter of the water supply line but no smaller than 1 inch.

Typical Uses: Bathtubs, sinks, swimming pool fill inlets, water softener discharge lines, fills for tank trucks and spraying equipment.

Figure 14-1



14.2.2 Reduced Pressure Principle Device (RPZ)

This assembly provides protection against backpressure and backsiphonage. The RPZ can be used under continuous pressure and in high-hazard conditions. It consists of two (2) independently acting internally loaded check valves separated by a reduced pressure zone.

Figure 14-2

Typical Uses: Plating shops, sewer plants, hospitals, and chemical plants, treated boiler systems, etc.

Maintenance: Most RPZ failures are due to dirt and debris, therefore, keep the device clean.

Inspection: There are three (3) test ports on the device used to check if the valves are properly working.

Testing should be done annually by an ASSE certified tester. Reliability of the device that it is protecting public health increases with regular inspection.

14.2.3 Atmospheric Vacuum Breaker (AVB)

AVBs allow air to enter the waterline when the pressure in the public system or the service line is reduced to 0 or below, however, since the vacuum relief valve is not internally loaded, the device must be installed on a discharge side of the shut off valve. AVBs should not be subjected to continuous flows for periods of more than 12 hours. They can be used in situations where no chemicals are added and are intended for backsiphonage potential only.

Figure 14-3

Typical Uses: Flush valve toilets, hose bibb outlet where a hose might be attached, dishwashers, janitor slop sinks, laboratory gooseneck faucets, beauty salon sinks, photo development machines.

14.2.4 Pressure Vacuum Breaker (PVB)

This device allows air to enter the waterline when the pressure in the public system or the service line is reduced to 0 or below. The device has a vacuum relief valve which is internally loaded, normally by means of a spring.

Typical Uses: Lawn sprinkler systems (no chemicals), photo developers.

Maintenance: Routine inspection according to manufacturers' recommendations. This device has two (2) test ports that must be checked annually by an ASSE certified tester to ensure its reliability.

14.2.5 Hose Bibb Vacuum Breaker

This device is used to protect primarily against back-siphonage at otherwise unprotected hose bibbs.

Typical Uses: Janitor slop sink, marinas, wash down hoses, swimming pools, and in general all hose uses.

Figure 14-4

14.2.6 Double-Check Valve Assembly

These assemblies are used for a direct connection between two potable systems and therefore have very limited application. This device protects against backpressure and back-siphonage conditions only if the cross-connection protection is from substances that do not constitute a health hazard.

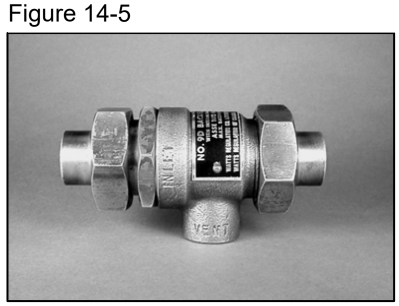
Typical Uses: Fire suppression systems with identical connections.

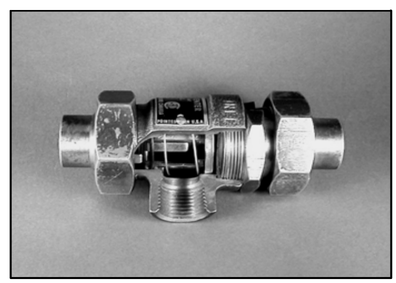
14.2.7 Dual-Check Valve with Intermediate Atmospheric Vent

This assembly is permitted for low or moderate hazard with small pipe sizes. It can be used to protect against backpressure and can be used under continuous pressure. A specific type made of stainless steel has also been developed for carbonated beverage application.

Typical Uses: Domestic boilers (no treatment), heat exchangers (no treatment), carbonators (see info below).

Figure 14-5





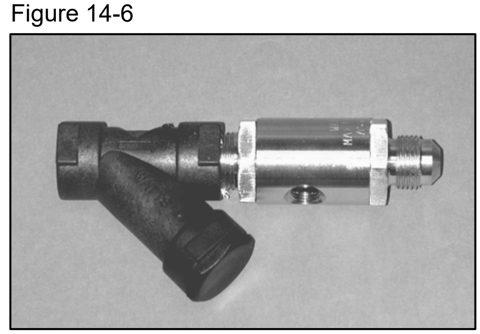
14.2.8 Beverage Machine Carbonators

The special backflow device for carbonators prevents the backflow of carbon dioxide gas and carbonated water into the water supply for vending machines, thus eliminating the hazardous reaction of carbon dioxide with copper tubing.

Backflow Preventer for Carbonator

Beverage Machine Carbonators' Backflow Preventer Installation Position.

Figure 14-6



Chapter 15

Safety and Emergency Issues

Everyone involved in the NCWS facility is responsible for maintaining a safe and secure environment. When tools are left lying around or when spills are left for someone else to clean up, accidents are possible. When a water pipe breaks or the well pump does not work, a plan must be in place to take care of the problem quickly. If the person in charge of the water system is not around, others need to know what to do and who to call in case of an emergency.

The federal government established minimum health safety standards under the Occupational Safety and Health Act of 1970 (OSHA). These standards require that every employer furnish employees with a place of employment that is free from recognized hazards that are likely to cause death or serious injury.

The Michigan Legislature created the Michigan Occupational Safety and Health Act, Public Act 154 of 1974 (MIOSHA), to better prevent workplace injuries, illnesses, and fatalities in Michigan. These occupational safety and health standards promote safety and health training for the workplace.

Confined Space Rule
This MIOSHA rule is intended to provide protection to an employee from traumatic injury. A confined space is an area where the oxygen supply may be of insufficient quantity or that harmful gases may be present and includes, but is not limited to, a bin, silo, hopper, tank, manholes, or well pit. MIOSHA standards involve tests and procedures which must be followed before entry into a confined or hazardous space. Oxygen and gas detectors are to be used to check the air quality and personal protection equipment worn by the individual entering the confined space must be appropriate.

Protective Clothing
An assortment of personal protection equipment is available to protect a worker on the job site. This equipment can be very successful in preventing serious injuries and include items such as: hardhats, safety goggles, safety-toed shoes, face shields, gloves, safety belts, aprons, ear protection, and respiratory equipment. The owner of the facility is responsible for making sure certain equipment is available for the worker, but it is the workers responsibility to use the equipment.

Electrical Safety
When electrical equipment or motors are to be worked on, it is important that the person doing the work “locks out” and “tags” all electrical switches and is the person to remove the lockout device and tag. Remember when doing electrical work not to stand in water as it is a good conductor of electricity.

Handling Chemicals
A person must be very careful when handling chemicals. Many chemicals used in waterworks facilities may be acidic or corrosive and can cause severe skin burns, permanent eye damage, lung damage and even death. A Material Safety Data Sheet (MSDS), which describes the physical properties and the health and safety hazards associated with a chemical should be located at the water supply facility for every chemical used or stored there.

Chemicals such as hydrochloric acid (industrial name, muriatic acid) may be used to loosen incrustations from a well casing and well. This chemical is an acid and is very corrosive. If using an acid with water ALWAYS add acid slowly to the water. Never add water to acid, a violent reaction may occur producing a lethal gas and acid could splash all over you. Chlorine is often used for water quality treatment. Appropriate safety equipment such as protective eye goggles and rubber gloves must be used when handling any chemical.

Housekeeping Items

Of course, there are other items that a facility owner and operator must be aware of when it comes to safety issues. Along with MIOSHA rules and standards that must be followed, comes common sense that will help protect the health and safety of all persons who visit the establishment. Keeping work areas clear of debris, sidewalks, and walkways in good condition, cleaning up water spills and messes are all things that should be done.

Emergency Action Plan

In the event of an emergency pertaining to the drinking water supply, it is necessary to act promptly and effectively to protect public health and welfare. In the context of this plan, emergencies could include complete loss of water pressure, contamination of water supply, and threats or observed vandalism to water system. Complete loss of water normally would require closure of the facility. Threats or contamination with unknown substances may also warrant such action. However, under certain situations where water is flowing but has been determined unsafe to drink by health authorities, it may be possible to operate the facility with approval of the appropriate local or state agencies. If approved, operation for an interim period is dependent on providing an approved source of water for consumption and notification to the users to not consume the piped water in the facility.

An emergency action plan includes information for immediate responses and may contain the following: an inventory of necessary standby personnel and equipment; obtaining an alternate source of water; public notification procedures; an inventory of contractors and suppliers; a method for notifying the local health department; and emergency repair procedures.

Emergency Action Plan
Noncommunity Public Drinking Water Systems

Emergency Plan Purpose: In the event of an emergency pertaining to the drinking water supply, it is necessary to act promptly and effectively to protect public health and welfare. In the context of this plan, emergencies could include complete loss of water pressure, contamination of water supply, and threats or observed vandalism to water supply. Complete loss of water normally would require closure of the facility. Threats or contamination with unknown substances may also warrant such action. However, under certain situations where water is flowing but has been determined unsafe to drink by health authorities, it may be possible to operate the facility with approval of the appropriate local or state agencies. If approved, operation for an interim period is dependent on providing an approved source of water for consumption and notification to the users to not consume the piped water in the facility. This fact sheet is intended to outline procedures and contacts to address such emergencies.

If a water emergency occurs, contact your local health department for further instructions.

System Information
Keep this basic information easily accessible to authorized staff for emergency response

Water System Name	
Water Supply Serial Number (WSSN) and Source IDs	WSSN IDs (ex: 001, 002, 003)
Population Served and Service Connections	Nontransient Persons _____ Transient Persons _____ Number of Connections _____

In any event, there are a series of general steps to take:

1. Analyze the type and severity of the emergency;
2. Act to save lives;
3. Act to reduce injuries and system damage;
4. Make repairs based on priority demand, and
5. Return the system to normal operation.

Emergency Contact/Notification Information
Contact the Local Health Department Staff to notify them of the situation as soon as possible or for help.

Contact	Name and Position	Telephone	Cell Phone	Email
System Owner				
System Operator				
Other Responsible Person				
Public Health Inspector (Local Health Dept.)				
EGLE District Staff				
Certified Testing Laboratory				

Contact	Name and Position	Telephone	Cell Phone	Email
Alternate Certified Testing Laboratory (for weekends)				
Well Driller				
Plumber				
Electrician				
Electric Utility Company				
Water Treatment Equipment/Chemical Supplier				
Gas/Propane Supplier				
Police/Fire				
Emergency Medical Services				
Engineer/Consultant				

Alternative Water Sources
An approved alternative source of water is required during precautionary measures when water supply is at risk.

Alternative Source	Names (where water is purchased)	Phone
Purchased water		
Bulk water suppliers for potable water use		
Tanker trucks in the area available to deliver bulk water for non-potable use		

Method of dispensing water to individuals in a sanitary manner:

Water Equipment
Other consumptive water uses or equipment that may be directly connected to the potable water supply.
Indicate if any of the listed water uses are in the facility and thus need to be addressed.

Type of Water Using Fixture	Yes or No	Location
Drinking Fountains to Shut Off		
Ice Machines (discard contents)		
Post Mix Soft Drinks to Disconnect		
Coffee, Tea, Juice, Soup, Vending, etc.		
Other		

Note: If the water supply loses pressure or cannot be used due to unsafe conditions, any equipment used for food service or consumption which is connected to the water supply will need to be disinfected per the manufacturer's specifications.

Public Notification
Consumers are to be advised of a problem with the water and availability of an alternate source of water for consumption.

Retain a copy of the signed and dated public notice. Send a copy to your local health department.
Consult your local health department for the required public notification language and format.

List locations to be posted (Post public notice at all sinks and any other potential drinking water outlets that cannot be shut off.)

List of persons who need to be notified (Schools, Child Care Centers, Children's Camps, are recommended to provide notice to parents.)

Media Notification List

Organization or Department	Name and Position	Telephone	Cell Phone	Email
Newspaper – Local				
Newspaper – Regional/State/Tribal				
Radio				
Radio				
TV Station				

You must have approval from your local health department prior to resuming use of your water supply for consumption.

Water Emergency Actions

1. Immediately limit access to all faucets that may be used for water consumption. If you have power and well pump can run, "bag" faucets or turn off water to the faucet.
2. Contact your local health department environmental health staff. Get instructions and public notice posting document.
3. Post all sinks where water may be used for consumption. Notify employees and customers not to consume the water. (No drinking, brushing teeth, or use of water in a food or beverage product).
4. Provide an alternate source of water (bottled) if your business stays open.
5. Contact service and repair contractors.
6. Repair system. Flush, disinfect and flush as needed.
7. Collect bacteriological sample and send to laboratory.
8. Collect second bacteriological sample 24 hours after first sample and send to laboratory.
9. Contact your local health department for approval to serve your system water to the public.

Response Actions for Specific Events

The following tables identify the assessment, set forth immediate response actions, define what notifications need to be made, and describe important follow-up actions.

A. Power outage

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

B. Treatment equipment failure

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

C. Source pump failure

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

D. Microbial (coliform, *E. coli*) contamination

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

E. Chemical contamination

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

F. Vandalism or terrorist attack

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

G. Reduction or loss of water in the well

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

H. Flood

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

I. Hazardous materials spill in vicinity of sources or system lines

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

J. Other

Assessment	
Immediate Actions	
Notifications	
Follow-up Actions	

Returning to Normal Operation

Description and Actions